THE JOURNAL OF
Engineering Education

January, 1953 Vol. 43, No. 5

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Published monthly (except during July and August) at Prince and Lemon Sts., Lancaster, Pa., by the American Society for Engineering Education under the Supervision of the Publication Committee: A. B. Bronwell, Chairman, Northwestern University, W. R. Woolrich, S. C. Hollister, C. E. Watson, Editor. Entered as second class matter, October 17, 1912, at the Post Office at Lancaster, Pa., under the Act of August 12, 1912. Subscription Price, $5.00 per year; Single Copies, $1.00.

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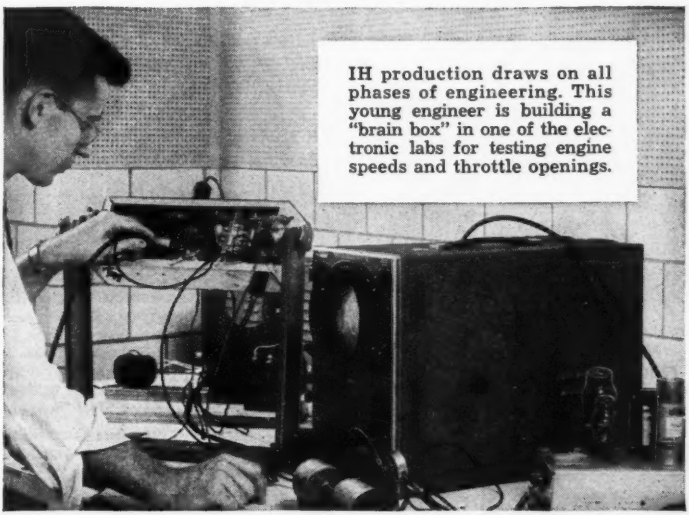

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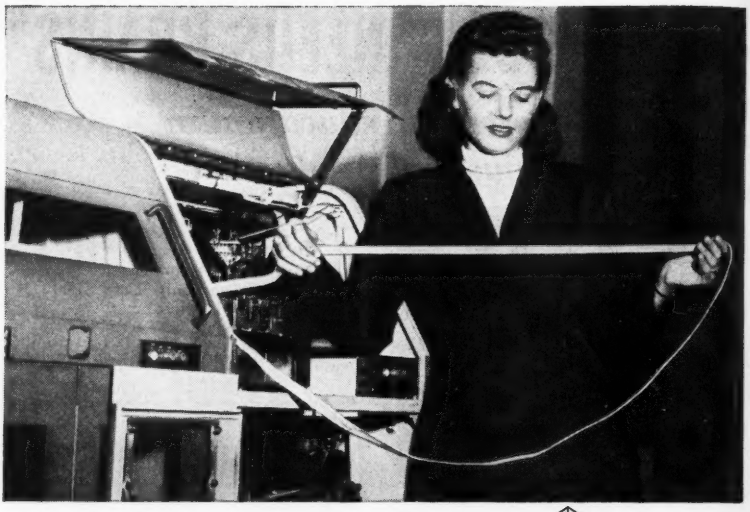

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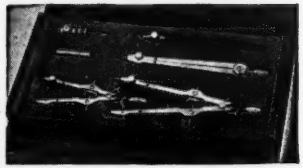

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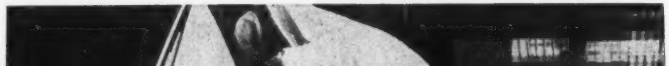

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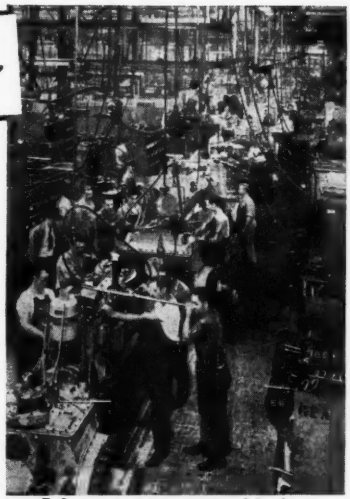

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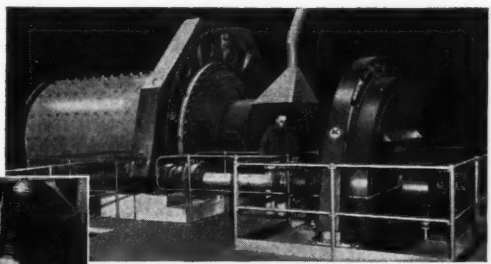

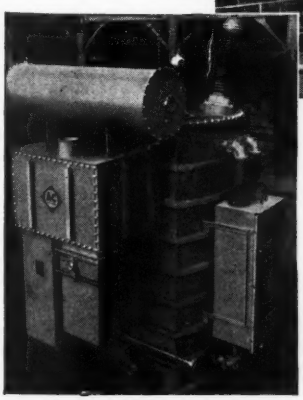

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Financing Engineering Education*

By JOHN D. MILLETT

Executive Director, Commission on Financing Higher Education, and Professor of Public Administration, Columbia University

Sponsored by the Association of American Universities and financed by grants from the Rockefeller Foundation and Carnegie Corporation, the Commission on Financing Higher Education was a private *ad hoc* agency set up for the sole purpose of making a study and reporting its conclusions about the financial problems confronting higher education today. The Commission carried on its work between 1949 and 1952, held its final meeting in July of this year, and has gone out of existence with the completion of its work.

One of the first conclusions we reached was that the financial problems of higher education must be analyzed in the first instance in terms of programs. To be sure, all the work of higher education is conducted through particular and individual institutions, whether they be universities, separate colleges, or separate professional schools. Although each of these is a self-contained financial unit, we have found in the course of our inquiry that their financial well-being must be considered in terms of the educational programs they provide. There are complications in this kind of analysis; thus the separate liberal arts college faces substantial financial difficulties which do not confront the liberal arts colleges of most universities, at least not in the same degree. The few separate medical schools still existing in this country, for various reasons, have financial problems different from those of medical schools in universities.

Let me illustrate with a few figures applying to engineering education. From the information I have there were 135 institutions with accredited engineering curricula in 1950. Of these 135 institutions, 92 were universities (57 public and 35 private), 11 were liberal arts colleges (1 public and 10 private), and 32 were separate engineering schools (18 public and 14 private). This variety of institutional settings has certain definite advantages. It means that there is considerable diversity in the environment and in the methods of engineering education; different institutions have somewhat different objectives or emphasis, such as upon instruction and research, and serve somewhat different clienteles; competition proves useful for education as for other types of enterprise.

Now institutions which offer very different kinds of educational programs cannot be compared financially, one with the other, as institutions. Their total cost figures or their total income figures are meaningful only in terms of the educational objectives they serve to realize, whether these be liberal, professional, or graduate study, or research. Accordingly, we have endeavored in our studies, insofar as possible, to think in terms of programs first and of institutions secondly.

To be sure, engineering education is one of the important professional programs of higher education in this country. It is one of the programs whose financial problems must therefore be analyzed in terms of the objectives, costs, and sources

* Condensed from a luncheon address at a joint meeting of the American Society for Engineering Education and the Engineers Council for Professional Development, Sheraton Hotel, Chicago, September 5, 1952.

of income peculiar to engineering education, regardless of its institutional setting. And there are certain common characteristics or certain common elements in the financial condition of engineering education wherever it is conducted.

Cost Problem

This brings me to the second point I wish to emphasize. A cost problem in higher education occurs when income for the support of a particular activity or institution is insufficient to meet the expenditures entailed in the operation. Because a particular educational program expends more money per student than another does not necessarily mean that the program is a cost problem. For example, the theological education of ministerial students is a high-cost program. It is not a cost problem because gift support from church denominations has generally met all the costs of providing theological education.

Medical education certainly entails no greater expenditure to an institution than does graduate education for the Ph.D. student in chemistry or physics. But medical education is by far the greater cost problem for higher education because sources of income have not been able to match expenditures. Indeed, of all fields of professional education, the experience of medical education is the most instructive for the college and university administrator concerned with costs and income.

Unquestionably, medical education is one of the outstanding contributions of all higher education. Some forty or fifty years ago medical educators, foundation officials, and leaders of the medical profession made quality the goal of medical education. The proprietary medical school was forced out of existence, the separate medical school was absorbed within the organizational framework of universities in order to give emphasis to medical scholarship, the number of medical schools was reduced, admission standards were raised, the period of medical education was lengthened, the curriculum was given a more or less set pattern founded upon such fundamental knowledge as existed in the biological sciences, the student-faculty ratio was lowered, and new attention was given to promotion of medical research. Insofar as educators have been able to agree, these are the elements which still go to make quality education in any field.

All of this effort costs money. Foundations and philanthropists were generous in their endowment support of medical education for a number of years. But in the past twenty years medical educators have clung to their concepts of high standards without evidencing an equal concern for adequate sources of financing. The result has been to create a crisis in financing medical education. Foundations and the federal government have offered large sums of money to finance research, but have defrayed only direct project costs. Indirect costs of plant maintenance and administrative overhead have had to come from general income. Mounting research expenditures have made medical schools research "poor," because they have not had corresponding increases in general income. Medical faculty salaries have gone up with increased remuneration from private practice, instructional supplies cost more, the medical curriculum has frayed out into more and more specialization. All of these developments mean more expense, which must be met by more income.

Higher education has no choice but to operate with a balanced budget. Medical education in public and private institutions has been kept at a high level of quality only at the price of diminishing the income available for other educational programs. Administrator after administrator in state universities and private institutions has testified to this fact.

The medical profession has taken great pride in the standards which medical education maintains in this country. But it has not manifested any equal concern with the costs which these standards entail, and

has assumed no real responsibility for finding ways and means to provide the income which medical education so direly requires today.

The third point I would make is this. As of the present time engineering education is not a major cost problem. As expenditures have risen, income has thus far been sufficient to meet required levels of outlay. The federal government has provided extensive research income, and the procurement regulations of the armed forces give adequate recognition to the element of indirect cost. Business corporations have recognized their direct interest in engineering education, and as the whole idea of corporation philanthropy has grown, engineering education has obtained a good proportion of these gifts, for current operations, for endowment, for capital plant, and for student aid. Increases in student fees and the generous support of higher education by state governments have also provided income to engineering education sufficient to meet most immediate needs.

Pressures are Accumulating

But if engineering education is not an immediate cost problem, it is one where many pressures are accumulating which suggest serious financial concern for the future unless more income is provided for its operation. Engineering education is tending to lengthen, especially to expect more students to continue into advanced graduate work for the master's, a specialized, or a doctorate degree. Engineering education is becoming more and more complicated, more and more highly specialized. This means more instructors with more varied educational background and experience. I have just been reading, for example, about the desirable qualifications today of an engineer to specialize in industrial control mechanisms based upon the feedback principle. I was astounded by the educational implications of this statement. Engineering education requires larger, better equipped laboratories than ever before. And instructional salaries must be increased in order to meet the competition of both industrial and governmental demands for engineering personnel.

All of these factors mean more expenditures. If we are to have the quality engineering education our society today needs and demands, then more income must be made available.

Where is the additional income to be found? For the public institution it must be obtained, first of all, from increased state appropriations. On the whole, the record of state support of higher education is a good one. The real tests are still ahead. State appropriations are supplemented by income from student charges, federal government research contracts, and even private benefactions. All of these must be employed by the public institutions in various ways in order to provide the income all higher educational programs must have, including the income essential to the further development of engineering education.

For the private institution the sources of available income are student charges, endowment, government contracts, and private benefactions for current operations. Student charges twice the levels which obtained in 1940 do no more than reflect the changes in price levels which have occurred in the past twelve years. On the whole, moreover, ability to pay for higher education is more widely distributed in our society today than ever before. There is still a need to provide assistance to the promising student of impecunious condition, but here too the current situation is reassuring even if not entirely satisfactory. The usefulness of endowment is by no means passed, and benefactors willing to make substantial one-time gifts, whether they be individual or corporate, must be encouraged to provide capital for future support. Most private institutions, moreover, need new physical facilities. For the moment, the requirements are for capital plant modernization rather than expansion. The instructional facilities of many institu-

tions are obsolete in terms of present-day educational needs. They must be replaced by much more modern classroom and laboratory buildings.

Government contracts have been extremely helpful in providing improved research facilities and in building up the research activities which are the base of much engineering education. The dangers are that some institutions have gone so far in rendering services to the federal government that they have almost forgotten their primary educational obligations, including their students. Moreover, institutions must continue to insist upon adequate allowances for indirect research costs if they are not to find research support a financial embarrassment. But no institution should ever become so completely dependent upon federal support as to jeopardize its financial future or its educational freedom.

Finally, there are various sources of private benefaction interested in providing income for current operations. Our colleges and universities of all types are only beginning to realize the potentialities of alumni funds. New foundations have sprung up all over the country, and many of these may well be interested in the support of various programs of higher education. As I have said before, corporation philanthropy is potentially a great new source of available income, and engineering education is peculiarly equipped to make an effective appeal for such assistance.

I should like to hope especially that the various professional engineering societies will maintain a keen interest in the financial well-being of engineering education. It is not enough to be concerned with educational quality, with desirable standards of professional competence and of institutional performance. This interest must be coupled with a constant endeavor to help meet the income needs which make educational quality possible.

No Reason to Despair

I see no reason to despair of the financial future of higher education in general, or of engineering education in particular. I am convinced that the American public can afford the kind of higher education which it wants. If our society wants low-cost, low-quality higher education, that is what we shall have. If our society wants high-cost, high-quality higher education, it will translate that desire into practical means of realization.

I have been told by the dean of one school of social work that this country is today spending 15 billion dollars a year through all public and private channels for welfare purposes, from old-age assistance and pensions to general relief and allied activities, including the operating deficit of hospitals. This is a gigantic sum. All our educational service from kindergarten through the Ph.D., public and private, spends only about half as much. Which in the long-run will contribute the most to the material and spiritual well-being of American society—these welfare, or these educational outlays?

But, if the American public is to want improved educational services, they must understand the needs, financial and otherwise, of our educational institutions and of our various educational programs. Here is the great challenge to the educational administrators and to professional groups today. What are they doing to demonstrate the essential income requirements of our educational effort in this country? When they have made their case, effectively and conclusively, they will find the necessary funds. This is still the promise of our society, and the hope for the future well-being of higher education.

The following five papers were presented at the ASEE–ECPD Conference in Chicago, September 5, 1952 in connection with the Centennial of Engineering. J. H. Lampe, Vice President of ASEE and Dean of Engineering, North Carolina State College presided. *Theme:* "1920–1950. What Are Contemporary Demands on the Engineering Curricula?"

What Are Contemporary Demands on Engineering Curricula?

Electrical Engineering

By W. L. EVERITT

Dean of Engineering, University of Illinois

Recent discussions of engineering education have focussed their attention on problems common to all engineers. This emphasis has led many to recommend that engineering should be taught as a unified program with no differentiation along technical lines. Others feel that any differentiation should be along functional lines, such as research, sales, operation, management, etc.

The word "specialization" has almost come to be an epithet with an emotional rather than a specific meaning, like the word "communism." Too often it is used to apply to what the other fellow is doing, which we don't like, while we insist our own specific attention to a particular area is "Giving examples to illustrate broad fundamentals."

Nevertheless, whether we call them specializations or not, curricula are overwhelmingly organized on the basis of technical divisions, many of which include optional subdivisions such as communication and power. The setup of this panel indicates that it might be fruitful for us to consider, as a group, the objectives of the major technical divisions, what has been happening during the past three decades, and where we are going.

The commodity of the electrical engineer, electricity, is of little direct use to man. Except as an unpleasant or serious shock, it cannot be observed by any of the physical senses. In this it differs from the products of the civil engineer, such as bridges, roads, and other structures, or the products of the mechanical engineer, such as automobiles, steam engines, and refrigerating and heating systems. Its study requires emphasis on imagination, understanding of classical and modern physics, and mathematical analysis. Electrical systems provide means for the transfer from one point to another of energy which is supplied initially in some other form, such as mechanical or chemical, and used finally also in some other form as mechanical, heat, or light. The energy may be transmitted primarily for the purpose of doing work, i.e., supplementing man's muscles, or for the purpose of transmitting information or making calculations or decisions, thus supplementing man's senses and brain power.

Electrical engineering has had a dramatic extension of its domain during the three decades under consideration. In 1920, almost all the attention was devoted to the problems of the generation, distribution, and utilization of power. During most of the period since that date, the power field has had a continual economic expansion. Engineering graduates have been in demand, and generally in short supply. The industrial advances have been made largely in size and efficiency; relatively few new devices or principles have appeared. The analytical changes of importance to curricula have been primarily in the area of network analysis, such as the use of symmetrical components, matrices, and tensors; in the extension of the two reactance method for analysis of

machines; in the use of electrical models or analyzers for the solution of complex problems such as stability; and in an integrated approach to electromechanical systems.

New Concepts and Applications

The dramatic increase in new concepts and applications in electrical engineering has occurred in the field of the collection, processing, and utilization of information. This development has found application in both the power and the communication industries. In this area, electricity has unique advantages. The development has taken place around the technology now called electronics. In passing, it might be mentioned that because information can be handled by devices which control small amounts of power, and because young technical devices, like young animals, are usually small, newly discovered physical principles find their most immediate applications in communication, using this term in a broad sense.

Information necessarily involves continual change; it is only through change that intelligence can be identified. Power systems, on the other hand, change slowly and less frequently. In the circuits of information systems, two alternative approaches have been developed to determine how they respond to rapid changes. One method is to analyze them on a transient basis such as by the use of differential equations; the other is to study their performance over wide frequency ranges. The two methods are tied together by the mathematical concepts of Fourier, LaPlace, and Heaviside.

As a result of these needs, increasing attention has been paid throughout this period to circuit phenomena, including various aspects of network synthesis, i.e., the design of circuits to transmit the signals required.

Circuits deal primarily with conduction currents—the guiding of electrical energy by solid conductors. With the invention of the vacuum tube, two new concepts commanded attention. One was the set of principles involved in convection currents, i.e., the transmission of electricity by electrons moving in vacua or in tenuous gases. Out of this developed the areas of electron dynamics and electron optics, a combination of mechanics and electric and magnetic fields. The electrons obey the Newtonian mechanics as modified by relativity, but the forces are due to electric fields, including the effect of the electron charges, and to motion in magnetic fields.

Equally important, the vacuum tube introduced new concepts of control impedance in circuitry. This type of active element required a new approach. The concept of control, when linear and continuous, makes the amplification of the complex signals possible. If the control is non-linear it introduces the principle of modulation, whereby signals can be shifted from one part of the frequency spectrum to another, so that a common medium can simultaneously carry many messages.

With the development of radio, attention was again focused on the electromagnetic field concepts of Maxwell, one of the most fundamental of all contributions. But these concepts require, for their full understanding, the relatively difficult mathematical language of vector analysis. Maxwell's equations, previously offered only to graduate students, have been made available quite generally to undergraduates, at least in communication options. Displacement currents took their place along side conduction and convection currents as important means for the transfer of electrical energy. Electromagnetic wave phenomena, both in free space and guided by wires and tubes, received more attention.

I cannot take time to cover the whole impact of this new thinking in what we now call "electronics." I include "servomechanisms" in the general field of electronics because its concepts are identical, although its mechanisms may or may not differ. Suffice it to say that we now use electronics not only to extend our sense organs in space and range, but also to

supplement our brain power. Electronic devices can be designed to think, in the sense that they can make decisions on the basis of a comparison between data which are picked up from physical situations of all kinds and transformed into electrical signals. After making such comparisons and decisions, they can also give and execute orders. Furthermore, they can compute, either as an exercise given them by human beings, or in the process of making their own decisions.

Modern industry is based on the supplanting of human labor by machines. Electronics contributes greatly to this end because it more and more provides the sense organs, nervous system, and brainpower for the control of the routine operations.

Effect of New Developments

What is the effect of these new developments on curricula? For one thing, they lead to justifiable skepticism of a program which treats all engineers alike. Such a treatment would almost certainly tend to freeze programs into more rigid patterns. The concepts of electronics include a wide range of fundamentals interrelated one with the other. In the early 1920's many electrical engineering professors, especially department heads, insisted vigorously that rotating machines taught fundamentals, while radio, which was to develop into electronics, was a specialized application. In institutions where electrical curricula were kept uniform, the teaching of electronics was delayed for years. But some of us were allowed to develop elective courses and options in which these new ideas, now recognized as most fundamental, were taught. If you are to have stimulating teachers, you must allow them to study and work with new ideas, even if the new idea is a recognition that Maxwell's equations are more basic than Ohm's law and that the vacuum tube is as important as the motor. They will also want to teach these new ideas to their students. If such new ideas are automatically labeled specialization and restricted to the graduate program, stimulation in undergraduate teaching will be lost.

The expansion of fundamental ideas has caused a progressive elimination of the "how" in favor of the "why." The modern electrical graduate is told little about the way things are done in industry; this he must learn in the particular company he joins after graduation. He is not instructed in "hardware" or shop processes.

In the teaching process the student is more important than the teacher, and the teacher is more important than his subject. The time has passed when we can have a da Vinci who takes all knowledge as his province. Research requires concentration in particular areas. If we are to have good teaching, professors must teach what they themselves are studying. This means that we will have to continue generally our branches of engineering. On the other hand, a special group of teachers, with a common purpose of unifying physical concepts in a wide variety of fields, will also find this a stimulating study, and so may provide an integrated program of great value. I doubt that this can become the general pattern, but we should watch these experiments with sympathetic interest and adopt the lessons which they will teach.

Science consists of asking nature for the reply to questions properly put. Science obtains new knowledge from nature. Engineering, on the other hand, consists in the solving of useful problems. Problems usually originate with men, and the recognition of the existence of a problem is an important step in its solution. The solution, in turn, is sought because of its utility.

As engineering teachers we are trying to teach our students how to recognize and solve *hard* problems. The only way to do this is to have our students solve such problems. This is substantially the essence of the "case" method recommended by many including the ASEE Committee on the Improvement of Teaching. An in-

dividual problem necessarily revolves around a particular situation. The situation may involve many concepts, but usually some area will predominate. The student must have an appreciable background in at least one area before he can tackle these hard problems. In electrical engineering we are interested in situations where electrical power or signals are of primary importance in the solution of the problem. If we teach our students how to solve hard problems in this area, experience has shown they can change over and solve hard problems in other fields, engineering or otherwise. It is important that in cultivating a particular field we emphasize to them that their training can be transferred, that the problems they will meet in life will always contain new elements.

Technical Areas

For the future, I see three particular *technical* areas which may need to be integrated into our electrical curricula. They are:

1. Biological and psychological subjects
2. Modern physics, particularly quantum theory
3. Statistics

Many of the new electrical systems find a counterpart in biological systems. For example, the theory of servomechanisms explains many operations in the animal world. Communication systems frequently begin and end with human beings. Many of the decisions on the physical details of a television system had to be based on experimental psychological studies of the nature of vision. If the electrical engineer is to work in these areas he will have to learn their language.

New developments will continue to draw on physics. Modern physics has increasing importance in such devices as gas-tubes and transistors. Our students will need to have this foundation for the electrical engineering of the future.

Information theory, noise, and radio propagation require the mathematical approach of statistics, a subject not generally stressed in engineering education. A place must be found for it.

Since problems of social and humanistic development are common to all engineers, they are being omitted in this discussion, although their importance is recognized. They must always be taken into account in planning any engineering curriculum. The big question will always be: How shall we make the best use of a student's time in preparing him for his profession and as a citizen?

Centennial Issues of the Journal of Engineering Education

The December and January issues of the JOURNAL OF ENGINEERING EDUCATION contain papers which were presented at the Centennial of Engineering in Chicago in September. Extra copies of these issues can be obtained for $1.00 per copy by writing to the American Society for Engineering Education, Northwestern University, Evanston, Ill.

What Are Contemporary Demands on the Engineering Curricula?

Civil Engineering

By HAROLD E. WESSMAN

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What are the contemporary demands on civil engineering curricula? Have our civil engineering teachers recognized these demands in setting the pattern of formal education for the civil engineers of today and tomorrow? Are significant changes needed? These are the questions which concern us today.

Thirty-two years ago, in 1920 to be exact, I was just beginning my civil engineering studies in the second year of the course at the University of Illinois. I had been attracted to this great engineering college by the name of Milo S. Ketchum, known to me at that time only as the co-author of a surveying book which had helped me in my early survey work in northern Illinois. I did not know then of Dean Ketchum's contributions to structural engineering nor did I have reason to know how fortunate was my selection of school.

Now, in 1952, as I look backward over the years spent in getting my formal education and the subsequent years of professional practice, teaching, and administration, I realize the tremendous influence exerted upon me and many of my contemporaries by a score of men at the University of Illinois. Fortunate indeed are those who sat in the classrooms of Hardy Cross, Westergaard, Talbot, Shedd, Wiley, Rayner, and other great teachers.

Many of you in the audience today at this Centennial Celebration honoring engineers and their achievements can look back and pay corresponding tribute to great teachers of civil engineering in other fine engineering schools. As we direct the attention of hosts of people throughout the world to the role of the engineer in making America what it is today, let us not forget that the fountainhead of our engineering achievements is an assembly of engineering teachers who have evolved an American pattern of education which in my opinion is unsurpassed throughout the world, a pattern which is characterized by flexibility, informality, and creative stimulus.

As I look over this audience and see many fine civil engineering teachers, as I recall many others who are with us only in spirit, and then, as I think of the thousands of students who have sat in the classrooms of these men and who have gone out and helped to remold America, I can reach no other conclusion but that civil engineering teachers are discharging in an outstanding way their responsibilities in engineering education. Possibly we could do better, but on the other hand, anyone who has travelled and lived in other parts of the world, knows that we could do infinitely worse.

Major Accomplishments

Let us recount briefly the demands of practice during the past thirty years by focusing the spotlight on a few major accomplishments. But let us keep in mind that these achievements are only symbolic of hundreds of lesser achievements, all of which bear eloquent testimony to the

vision and creativeness of civil engineers.

This has been the era of the Empire State Skyscraper, the Holland Tunnel, the Pennsylvania Turnpike, the Tennessee Valley Authority, the Mississippi River Control, the Golden Gate Suspension Bridge, the Grand Coulee Dam, the Columbia Basin Reclamation. This is the period of sewage treatment in Chicago on an unprecedented scale, of huge slum clearance and housing developments in New York City. This is the period marked by the greatest war in the world's history, a war which was won primarily by the technology of America. It was a war characterized by the construction of vast American military bases from the far-flung islands of the South Pacific to the frozen wastes of Alaska, from the burning sands of North Africa to the towering mountains of West China.

This is also the period of through highways, of airports mushrooming over the length and breadth of our country, of the birth of structural aluminum, the erection of huge industrial plants, and the development of photogrammetry. In all of these, the civil engineer has played a leading role. Has he been weighed in the balance and found wanting? Have there been serious deficiencies in his education?

I was talking to a leading consulting civil engineer in New York City only a few weeks ago. He was the head of a firm employing several hundred engineers. I told him that I had just returned from the convention of the American Society for Engineering Education in Dartmouth and that we were reviewing again the educational pattern of engineers as is our mission in this Society. He said, "Why do you need to change civil engineering education? Look at the men that you have graduated during these past years." He cited a number of names of men who were doing outstanding work with his organization and went on to say, "There is nothing radically wrong with our American system of engineering education when it turns out such men."

When we study the nature of the work of the civil engineer today, we find that even though projects have increased in magnitude, the job functions are essentially the same today as they were 30 years ago. Civil engineers still have to design bridges and buildings, build highways great and small, develop water supplies, dispose of sewage, plan municipal developments, erect dams and reclaim the land. These are the things which they have done for years and will continue to do. But that does not mean that the products of their work in directing the forces and materials of Nature for the use and convenience of man are the same today as they were 30 years ago. Nor does it follow that our technical education, our teaching, has remained static even though the fundamental tools of mathematics and mechanics are the same. Due to research and study we have new knowledge about old things; we have new materials and processes; we have better methods of analysis; we know more about the properties of materials and the behavior of structural elements. We know more about the forces of Nature. These advances in knowledge are reflected in constant changes in the content of civil engineering courses, even though the titles of courses are the same, which is as it should be because of the nature of civil engineering.

Civil engineering education has always been alive and responsive to the demands of the profession and to the results of its research. One test of the vitality of an educational program is found in the answer to the question: "Does the program of engineering education and the associated college research lead and inspire practice?" If one studies the history and development of civil engineering education objectively and honestly in the light of professional practice, the answer to this question is unequivocally, "Yes." In fact, one of the reasons why this is so is that most of the research in civil engineering is either concentrated in the colleges or is handled by public agencies which are

guided by advisory boards on which college teachers are represented. There is relatively little private industrial research such as is found in the electrical and mechanical fields.

Educational Content

Let us look briefly at various branches of civil engineering and see whether educational content has changed in the past few years and whether the work of college teachers has influenced and dictated practice. Recall if you will, the work of Talbot at Illinois, Shank at Ohio State, Turneaure at Wisconsin, Lyse at Lehigh and Gilkey at Iowa State in the field of reinforced concrete. In fact, I find myself embarrassed at this point because there are many people in this audience who have contributed to a better knowledge of the nature of concrete materials and the behavior of reinforced concrete structures and whose work has resulted not only in better teaching but in better design practice. They should all be named.

In the field of structural theory, it is only sufficient to mention the name of Hardy Cross. But again, I must apologize to a host of contemporaries, many of whom came under the influence of Hardy Cross, and all of whom have contributed something in their own right to structural theory and design. The tremendous impact of Hardy Cross, however, upon civil engineering teaching and practice is particularly manifest when we note that his methods of analysis of structures are not only being taught in practically every school in the country but are being used in practically every structural design office in every large city in this country.

In hydraulics or if you prefer, in fluid mechanics, added vitality has been brought to the teaching and to the laboratory training of civil engineering students primarily because of the influence of a group of Freeman Scholars, some of whom were graduate students under Professor Cross. These men went abroad in the twenties and combined that which was best in European laboratory practice with their own American background. As a result, we have developed the finest hydraulic laboratories in the world, laboratories in which theory and experiment have gone hand in hand to give us new knowledge about the behavior of water and other fluids, knowledge which has been reflected in teaching and in practice.

Think if you will of foundation engineering which, even though glorified by the semi-science of soil mechanics, probably involves more of that intangible known as engineering judgment than any other branch of civil engineering. The names of Terzaghi and Casagrande come to mind immediately but again as I look over this audience, I see a number of engineering teachers who have contributed new knowledge in their own right even though their initial stimulus came from the Harvard Graduate School. They would be the first to admit that our knowledge now is not exact, but nevertheless is better than that which we had thirty years ago. The work of these teachers has changed both college courses and design practice in foundations.

The problems of water supply and sewage disposal are always with us. Is the content of these courses the same as it was 30 years ago? Do we still teach wheelbarrow methodology in construction engineering? How about highways and airstrips? Look at the *Proceedings of the Highway Research Board*—in fact, scan the Journals of all of the technical societies associated with the branches of civil engineering. There you will find ample evidence that the research of civil engineering educators, research which is inevitably reflected in the courses which they teach, is something which has gone far beyond the confines of the Ivory Tower in leading and in influencing the practice of professional engineers in America.

It would be a simple matter to list the names of 200 outstanding contemporary teachers in civil engineering who have played a part in keeping civil engineering

education alive and responsive to the changing needs of our civilization. Some of them will be found on the list of recipients of the Lamme Award and the Westinghouse Award for significant contributions to engineering education. In fact, most of the Westinghouse Awards to young outstanding teachers have been to civil engineering teachers. The citations accompanying these Awards bear eloquent witness to the collective impact upon engineering of only a few of my Honor Roll of 200 names.

What of the future of civil engineering education? Some say we need more science, in particular more mathematics and more physics, in order to give our students a better grounding in basic principles. Perhaps we should have more mathematics and more physics for some civil engineers enrolled in graduate study in certain special areas. Should we have it for all undergraduate students? I believe not. In fact, there is no room for more science courses as such in the four-year undergraduate curriculum. Let me hasten to add that this is not an argument for a five-year undergraduate curriculum.

There is a danger lest in the attempt to make better scientists out of our engineering graduates we make them poorer engineers. Hardy Cross in his book, "Engineers and Ivory Towers," states: "The systematized, formalized procedure called science, which is supposed to lead inevitably to unquestionable results, contrasts with the flexible independent creative instinct which produces art"—and which motivates the true engineer. Science points toward a unique solution, whereas an engineering problem usually has many solutions which must be compared in the light of related economic, social, legal, yes, even psychological factors. Of course the engineer should use the scientific tools at his disposal, use them efficiently and well. But I question whether a course in differential equations for all civil engineering undergraduates, a course taught by mathematicians, will help them appreciably in solving their engineering problems.

Five Great Problems

There are at least five great problems confronting the civil engineer of the future. The first and probably the worst is traffic congestion in our large cities. The second is municipal rehabilitation, of which slum clearance is only a part. All one needs to do is travel in the four-mile-wide belt around the heart of this great city of Chicago to know what I mean. The third is adequate water resources. The fourth is industrial pollution. The fifth is highway reconstruction and safety. These are not alone the problems of the civil engineer, but nevertheless the civil engineer has a primary responsibility in their solution and I doubt if more mathematics and more physics in the college curriculum will turn out engineers better able to cope with them.

One of the most difficult tasks confronting the teacher is the stimulation of the creative instinct in the engineering student. One way to accomplish this is to incorporate elements of project design and development wherever possible in our engineering courses rather than rely on the use of isolated problems. The project method encourages vision and imagination. But let no one delude himself into thinking that the project method is a recent discovery. I can name five of my teachers who used it in their courses at the University of Illinois 30 years ago. Outstanding in particular were the projects of Professor Shedd in his bridge design courses.

There is no question however, but what a more widespread use of the project method is desirable. Our students must learn, for example, that the design of a highway involves many other factors than the design of the sub-grade and the paving and the bridges and the culverts. We design arterial highways so that traffic can travel more quickly between cities but these same through highways bring more traffic quickly into the hearts of cities with the result that the streets in the business districts have now reached the

saturation point and are choked beyond capacity.

Civil engineers are faced more and more with the necessity of a broad approach to a problem. Too often have we seen one problem solved at the expense of creating a worse one. It is negligence of the worst sort to design and erect a modern industrial plant without provision for the safe disposal of its waste products.

Can we do the right kind of an educational job in a four-year undergraduate curriculum, with additional years of study for only those who desire graduate degrees? A man may become a good structural engineer or sanitary engineer or highway engineer after completing a four-year civil engineering curriculum, but the evidence seems to indicate that he would be a better engineer in any one of these branches if he had a fifth year of specialized graduate study. In fact, many civil engineering students would profit by a fifth-year curriculum in industrial management. But this is not an argument for a five-year course for all engineers. I believe that the recommendations of the 1940 ASEE Committee on Aims and Scope of Engineering Education relative to the four-year undergraduate program for all, and graduate study for those best qualified, are fundamentally sound. These same recommendations were endorsed by the 1944 ASEE Committee on Engineering Education after the war. They were further supported by the 1944 Committee on Engineering Education of the American Society of Civil Engineers.

I do earnestly believe, however, that a larger percentage of civil engineering students should be induced to elect a fifth year of advanced study. However, let us not forget that the education of an engineer is never completed, not in five years or even ten years.

Some of these discussions over engineering education are like the early arguments between religious denominations. "We are the true sons of God, the real defenders of the faith. If you want to get to heaven, this is the road you must take," cries one sect.

"No, that is the sure road to hell" is the rejoinder from another group. "We will show you the path to salvation." We may thank God that a Christian spirit of tolerance and considerate judgment have in recent years brought not only religious groups but educational reformers closer together in recognizing that there is no one specific prescription to achieve our goal. We all want to give our young engineering students the best possible education, and if we keep our programs alive and responsive to the changing needs of society and the dictates of new knowledge, then by the same process of evolution which has characterized our development in the past we will continue to fulfill our mission.

Third Midwestern Conference on Fluid Mechanics

TIME: March 23, 24, 25, 1953.

PLACE: University of Minnesota, Minneapolis, Minnesota.

SUBJECT MATTER: All features of theoretical and applied fluid mechanics.

What Are Contemporary Demands on Engineering Curricula?

Mechanical Engineering

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The genius of the mechanical engineering profession has been in the past and must continue in the future to be focused primarily on two things. The first is the release of energy and the production of power from fuels. The second is the conception, manufacture and distribution of machines to utilize this energy. The present standards of Western Civilization stem from the release from human toil made possible by the use of this power. The energy is derived from 2 gallons per person per day of petroleum and 32 pounds per person per day of coal. The power is dependent upon the ingenuity to make and distribute devices that enable this energy to perform routine tasks. There are known requirements for the continued success of this entire operation. It is necessary to maintain a sound economic system under which these benefits do not price themselves out of the reach of those who work to bring them about. Also, the resulting gains must be used to increase the nation's accomplishments and not to promote its indolence.

The period of 1920 to 1950 was marked by an ever-widening vision of the mission of mechanical engineers. Such things as the national resources of materials and purchasing habits of consumers became a part of a designer's consideration. The reduction of manufacturing and distribution costs assumed a significance beyond that of merely affecting selling prices. A National depression and a World War during this period did much to make mechanical engineers conscious of the social significance of their work. Enthusiasm for this trend in thinking has led to the addition of many Arts College type courses to mechanical engineering curricula. Students still view such courses as being a separate requirement distinct from their engineering education. In general the students are probably correct. The teaching profession has yet to find ways of making such courses into a natural part of an engineering training.

The period of 1920 to 1950 saw rapid advances in mechanical engineering technology. Entire areas such as heat transfer and system control that were no more than arts in 1920 became well developed fields of science by 1950. In other fields such as heat power, application changes came so rapidly that the entire teaching emphasis had to be changed. The advances in all technical areas demanded a higher proficiency in mathematics and a wider knowledge of physical science. That this occurred during a period of decreasing emphasis on mathematics in American secondary schools magnified its significance.

Curriculum Crowding

The simultaneous widening and intensifying of demands on mechanical engineering education have posed serious problems of curriculum crowding. Various methods of solution have been proposed. To

merely add a year to the four-year curriculum is a tempting one. But at a time when this Nation faces a serious world situation with a deficient supply of talented young men and when each youth is faced with from one to three years in the military service of his Country, such a simple solution as a universal five-year curriculum is not the answer.

A second quick solution is being also urged on college administrators. It amounts to practically the elimination of departmental senior year courses as they now exist. The proponents of this course of action believe these senior year departmental courses to represent an unjustifiable attempt at specialization in a four-year curriculum. Those who know what actually lies behind rather specialized sounding course titles evaluate these courses at their real worth. In a modern mechanical engineering curriculum these senior courses carry a major share of the training in engineering methods of working. In these courses students learn something of the art of bringing all of their knowledge, logic and experience to bear on a situation and learn to discipline their minds to hours of sustained logical thinking. It is here that they learn that engineering situations have multiple instead of single solutions and that science can aid but never replace sound judgment. This second solution to the curriculum crowding is unacceptable to mechanical engineering teaching departments who must stand responsible before the world for the performance of their graduates.

The broadening and intensifying of mechanical engineering education by a procedure of careful re-evaluation and selection must be followed, but it must proceed more rapidly in the immediate future. To be successful, such a process of re-evaluation must be carried out against a background of sound premises as a guide. To begin with, such a curriculum must be designed with the idea that each student is aiming at professional competence as a mechanical engineer. There is much talk of a watered down program designed for those students who do not aim to follow the profession but who desire merely a mechanical engineering background. It would be possible to give such students a general background of physical science in a reduced number of courses but a background in mechanical engineering is, by definition, the ability to think as a mechanical engineer. If a more painless way of achieving this were known it would be used on all mechanical engineers.

In the second place such a program must be designed with the idea in mind that each student will at some time in his professional career supervise others. Since supervision is the act of multiplying a person's usefulness by having him guide others, he first must possess abilities worth multiplying. Next, he must be taught to view life in a broad way and to comprehend and consider other human beings before he deserves the right to influence their lives.

In the third place a balanced curriculum must clearly recognize the great difference between the mere possession of factual knowledge and the ability to apply it to useful purposes. The art of logical thinking cannot be developed without accurate facts to think about. Inventive ingenuity and analytical skill, to be productive, must feed on accurate facts but they can both be foundered by an excessive emphasis on the accumulation of a knowledge of facts. The present extent and rate of growth of technical knowledge in all the areas of mechanical engineering must be admitted to be beyond the mastery of any single individual and far beyond the capacity of students. A balanced mechanical engineering curriculum cannot, therefore, be one that covers all related areas of technology. Rather, it must be one which teaches students to gather facts, analyze situations and evaluate solutions in each general area of mechanical engineering.

Over-Specialization

Over-specialization of a curriculum can appear in various forms. It can refer to

an unbalance in time distribution between the three areas of power development, design and manufacture, and economic, political, and human aspects of production and distribution. It can appear as an over-emphasis on the accumulation of factual material in any field with a corresponding deficiency of time for a student to learn to reason from these facts. With the present enthusiasm to make more of a scientist out of an engineer it could also take the form of over-specialization in a knowledge of mathematics and science far beyond the training in applying it. It can even occur locally in a curriculum in such a form as the concentration of all mathematics in the first two years, long before its uses can be comprehended.

Even after it is admitted that a mechanical engineering curriculum is to be constituted only of organized course sequences in each of major areas, the situation is far from being resolved. At the moment and by virtue of its historical seniority, power development with its ramifications is usually over-specialized in most curricula. It is over-specialized in two ways. Not only does it receive more than its share of the available curriculum time but also far too much of a student's effort goes into a familiarization with the physical facts of the subject and not nearly enough time in gaining experience in solving engineering situations of a comprehensive nature. This over-crowding of courses by a knowledge of physical facts reflects a combination of an inertia against discarding obsolete information, an eagerness to add new information and a reluctance to reorganize the working concepts and methods of presentation.

The second major area of mechanical engineering, the processes of conception design and manufacture of devices, is usually so dispersed around a campus as to lose much of its possible effectiveness for students. They study at one time or another many details that are involved in evolving a product to fill a need but only in retrospect, if at all, are they able to put the pieces together and see the sequence of steps involved. This situation is rationalized by insisting that after all, designing is an art that can be mastered only be practice after graduation.

Between 1920 and 1940 the design aspects of such courses as power plant design, combustion engine design, and heating design disappeared. By 1950 only machine design remained and it had become restricted to the mechanics of the metal parts of machines. Simultaneously, separate and often completely independent courses in shop processes, manufacturing methods, and production procedures came into being. Now all products must be conceived for their function, be proportioned for their use and be manufactured for their market, and these three things are not independent considerations. Mechanical designers must project their minds into new situations and simultaneously weigh all of these factors. Regardless of the organizational changes that become involved, educators must find ways to develop design as a broad process of mechanical engineering. The output of talented graduates with a developed interest and ability in design is far below the minimum needs of industry and well below the potentialities of the American youth entering mechanical engineering departments.

As early as 1920 there was serious concern because engineers were not making contributions to the social adjustments demanded by mass production in manufacturing. With reduced production costs eliminating skilled trades and in some cases actually driving up distribution costs, there was and still is fear that the machine may thus defeat itself. In searching for reasons for the ineffectiveness of mechanical engineers in this area it was first decided that engineers did not write or speak well enough. It was concluded that their knowledge of costs, purchasing and distribution was inadequate. There was a growing conviction that engineering thinking did not include enough understanding of practical everyday relations with people in industry and business. Between

then and 1950 the curriculum time aimed at this area of instruction was increased to as much as one-fifth of the total. The results, to date, are far from what were hoped for. Instead of courses adapted to fit into engineering curricula in a manner to be of direct value to engineers, the year 1950 found these courses more nearly corresponding to an Arts College minor and diverging further and further from the original objective. Neither the mechanical engineering teaching departments nor engineers in industry are favorably impressed by the results realized to date because the original aim has not been achieved.

Demand for Graduate Study

The steady increase in technical knowledge between 1920 and 1950 produced a greater and greater demand for graduate study, particularly at the master's level. It also resulted in a marked change in the nature of graduate study. The amount of formal course work increased as the individual project work decreased. This has continued until in 1950 many schools no longer require even a thesis in a masters program.

This same trend can also be seen in the undergraduate program. The undergraduate thesis disappeared, and the number of project courses decreased as the percentage of formal subject matter courses became greater. Irrespective of the merits or faults of subject matter courses and old project courses this represents a trend away from the emphasis on the training of the individual student toward an emphasis on subject matter mastered. This, coupled with a steady decrease in laboratory and supervised design and problem periods, should be reviewed thoughtfully. At a time when there is a recognized need for more originality, creativeness and individual ingenuity among mechanical engineers it would be sad indeed to be turning out a generation of students who could analyze and criticize ideas with great skill if only someone else would have the ideas.

Reserve this date . . . .

June 22-26, 1953

ANNUAL MEETING

UNIVERSITY OF FLORIDA

GAINESVILLE, FLORIDA

What are Contemporary Demands on the Engineering Curricula?

Chemical Engineering

By GEO. GRANGER BROWN

Dean of Engineering, University of Michigan

Engineering is the "Art and Science by which properties of matter and sources of power in nature are used by man in structures, machines and manufactured products."

Art is "skill or ingenuity in the adaption of things in the natural world to the uses of human life."

Science is the "accumulated and accepted knowledge which has been systematized and formulated with reference to general laws."

Putting these definitions together, it is clear that engineering combines the skill and ingenuity with a competent knowledge of the general laws which summarize our knowledge of matter and energy and their applications to structures, machines and products.

When Chemical Engineering curricula came into being about fifty years ago they were primarily industrial chemistry with a few courses in mechanical engineering added to give them an engineering flavor. At that time the practitioners were generally graduates of chemistry curricula and many such held that the best preparation for Chemical Engineering was graduate work in Chemistry as there was no particular knowledge concerning the processing of materials which had been accumulated or formulated with reference to general laws. The Chemical Engineer, having no science of his own, therefore, relied almost entirely upon the Science of Chemistry and the Art of the Mechanical Engineer. This was a successful combination and the Chemical Engineer made important contributions in solving new problems created by the first World War and the rapid development of the chemical, petroleum and other process industries immediately thereafter.

Perhaps because of their roots in chemistry, Chemical Engineers are avid experimentalists and acquire extensive data on their operations. Imbued with the scientific spirit, they correlated these data on similar operations in different industries on the basis of the Unit Operations as suggested by A. D. Little in his report to the Massachusetts Institute of Technology in 1915:

> "Any chemical process, on whatever scale conducted, may be resolved into a coordinate series of what may be termed "Unit Operations" as pulverizing, drying, roasting, crystallizing, filtering, evaporating, etc. The number of these basic unit operations is not large and relatively few of them are involved in any particular process. The complexity of Chemical Engineering results from the variety of conditions as to temperature pressures, etc., under which the unit operations must be carried out in different processes, and from the limitations as to materials of construction and design of apparatus imposed by the physical and chemical character of the substances being treated."

Armed with these correlations, the Chemical Engineer was able to solve the problems of processing new materials

without any previous experience in such processing. The only new information required was a limited knowledge of the properties of the material to be treated. Frequently even these had to be estimated due to the limited amount of the material available for experiment. This ability was dramatically demonstrated by the chemical engineers of the du Pont Company in the design, construction and operation of the nuclear reactors and plutonium processing plants at Hanford in 1943. As the science of the unit operations developed from 1920 to 1950, it gradually displaced the old technology courses which aimed to acquaint the student with industrial practice in particular industries, which were generally treated according to the chemist's classification of organic and inorganic technology. The quantitative more general study of the unit operations gave the student more power to solve new problems in new industries.

Undergoing Simplification

The more complete our knowledge the simpler is the framework which can be used for systematizing the accumulated facts. The unit operations themselves are undergoing simplification. Absorption, stripping and fractionation are now treated as one operation known as vapor-liquid transfer but applied for different purposes; and vapor-liquid transfer is further being closely associated with the corresponding liquid-liquid and liquid-solid transfer operations. Fluid mechanics is being studied and may become a common fundamental science covering all fluid, mass and energy transfer operations such as fluid flow, mixing, mass transfer and heat transfer.

On the other hand, as more knowledge is accumulated and accepted, the teacher is frequently persuaded that he must have more time to acquaint the student with this additional knowledge. This is perhaps particularly true in Chemical Engineering because of its additional background in Chemistry as well as Physics. But this point of view overlooks the most important characteristic of Science, that is, the systematizing and formulation of knowledge with reference to general laws. As science advances, our general laws become more reliable and with a more complete understanding of the basic general laws a much better understanding can be given the student in less time if the curriculum emphasizes the general laws of science and their use in arriving at solutions to engineering problems rather than attempting to cover the accumulated and accepted knowledge that is available. The latter approach tends to develop an ability to solve only those problems which have been solved, while the former tends to develop an ability to solve those problems which must be solved. Was it Einstein who said, "Scientists are those people who solve the problems which they can solve, and engineers are the people who solve the problems which have to be solved"?

The decisions in design, construction, management and operation usually based on incomplete data, but made on the basis of judgment, ingenuity and experience generally guided by an appreciation of the fundamental general laws of science are the highest form of engineering combining Art and Science.

There are two exacting demands on contemporary chemical engineering curricula in the presentation of science. The first is to emphasize and develop an understanding of the basic general principles which consititute true science and to forego the teacher's desire for complete presentation of his knowledge. This must be reserved for post-graduate courses in special fields. A firm foundation in the general laws of science is also an excellent background for graduate study as well as for the practice of engineering. Second, because the student is to be prepared for engineering practice in the future twenty to thirty years, and because the frontiers of science today are the accepted basic principles of engineering practice tomorrow, the student should be exposed to the most modern thinking in

physics and chemistry, and not simply to those well established principles which he might be called upon to use today. The college or university is the best opportunity afforded the student to become acquainted with these modern concepts.

The standard freshman or sophomore course in Physics frequently divided into the five divisions of Mechanics, Heat, Sound, Light and Electricity, and following the plan of instruction which has been in vogue since the Spanish War generally fails to meet either of these demands. It may have the opposite of the desired effect by emphasizing the differences in the various subdivisions.

Technology presented as descriptions of and current industrial practice has no place in a curriculum in chemical engineering except as examples in the application of general principles. Such descriptive technology taught in school is almost certain to be obsolete by the time the student reaches a responsible position in practice, and current industrial practice is best learned on the job.

Requires Practice

The Art of Engineering requires practice and the student should be given some practice at least in the last year in the recognition and definition as well as the solving of engineering problems. Such problems should be presented in general terms so the student must first resolve and define the problem and then arrive at a reasonable solution with incomplete and frequently confusing data. The willingness to tackle such problems must be developed in the student, and this seems to require that the assigned problems have some factor or slant which has not been discussed or explained in class or in the text; otherwise the student feels abused and resentful if called upon to do some original thinking. The complaint that "we never had that before," or "you never told us that" may be an indication that the proper type of problem has been assigned.

This ability to take the responsibility for a solution based on incomplete data and thereby create a new process or a new design is the major outstanding characteristic of the engineer. It can be acquired or developed as witness the number of individuals trained as scientists in Chemistry, Physics or Mathematics who become successful engineers by acquiring this skill or ingenuity and experience. But it is necessary to be certain that the graduate engineer has at least a certain minimum of this art by requiring him to demonstrate his ingenuity in some creative project before graduation; otherwise he may be a mere scientist equipped with tools but unable to use them.

There are many other collateral demands in addition to the general scientific background and experience in creative work such as the design of a new process which must be satisfied if the curriculum is to be wholly adequate. The development as well as the expression of ideas requires the effective use of language of some kind. When we say a man thinks in English or in German or in Mathematics, we mean exactly that. Language is a tool for thinking as well as for expression, and the engineer uses at least three languages for these purposes: English or his native tongue, Mathematics to an ever increasing degree, and graphical presentation or drawing. To be effective the use of language must be precise and easy. This requires constant and careful use. Therefore, the student must always be required to use, and use correctly, these three languages in his professional course. It will not do to delegate the responsibility for the correct use of English to the English Department, or for Mathematics to the Mathematics Department, or for Drawing to the Drawing Department and then ignore these matters in the professional courses any more than it would be considered satisfactory to ignore the principles of science developed in the basic science courses in teaching the professional engineering subjects in the senior year. Such practices undo all the good work of

the English, Mathematics, Drawing and Science Departments and give the student the idea that having completed these courses, he now has no further use for them and instead will concentrate on his professional work.

Teamwork is Essential

Practically no engineering graduate fails in industry because of technical inadequacy, but many fail of realizing their potential success because of inability to write effective reports, to present their ideas effectively before a Board, or to work smoothly with their associates. This last requirement leads to another important demand on modern chemical engineering curricula, to train and develop the student to work well with his associates. This cannot be done if he is always required to do individual work throughout his entire college program. Any number of courses in psychology will accomplish practically nothing compared with actual experience in working with others. Perhaps this is a major advantage in the cooperative curricula if the student learns to work with others during his apprenticeship in industry. But much can be done in requiring students to work in squads in many courses in the normal full-time program. The senior laboratory and design courses are excellent opportunities for this experience which also has advantages in developing technical ingenuity.

The requirement for admission as a candidate to the doctorate in Chemical Engineering at Michigan has included for many years the preparation of a satisfactory engineering report which includes the design for a new process. This is known as the twenty-one day problem because of the time allowed. One of these involved the economics of recovering the solvent from extracted bean meal. The successful graduate students and the faculty had come to believe that such a process was not economical. In the course of time this doctoral problem became a senior project in which the seniors work in groups of three as separate firms of consulting engineers. One resourceful group of seniors went into the laboratory, obtained some data, and established the fact that it was economical to recover the solvent if the dried unextracted beans were used to absorb the solvent vapor.

Furthermore, it must be remembered that the faculty are teaching men, human beings, and not simply technical subjects or worse yet simply certain textbooks; and that these men must have some human interest other than their technical problems. Industry and the world is made up of human beings and the engineer is a much better engineer if he has fully developed human interests. These are generally best developed by voluntary activities on the part of the individual in participating in extra-curricular activities such as debate, sports, editorial work, and in courses in the humanities such as history, literature, philosophy and music. The student must be given an opportunity and encouragement to develop and pursue these interests. But this should always be on a voluntary basis and such courses should be handled as electives. Otherwise, they are frequently regarded as simply additional hurdles to be overcome.

Instruction Must Be Streamlined

To meet these contemporary demands, the undergraduate instruction must be streamlined. We must recognize the advances that have been made and are being made in all fields and continually revise our presentations to eliminate all that which is not absolutely essential.

Some months ago the college of Pharmacy was celebrating its seventy-fifth anniversary and in looking ahead to the future years, there was considerable discussion that the curriculum would have to be lengthened to at least five and probably to six or seven years to include all of the new facts and information being developed in the field of pharmacy and the necessary humanities to make a well rounded citizen. President Hatcher, who is a recognized scholar in Literature and History, was then called upon to close

the meeting. He commented that 150 years ago the entire offering of courses at Harvard College, including a list of the text books used, was printed on one and one-half pages of a small book-size pamphlet while at the present time a large modern university offers 4000 courses. To take advantage of all of these offerings one individual would attend classes for three hundred years. When he studied history a three hour course might cover five hundred years or more of history but now such courses cover fifty years and we might look forward to the time when a fifteen weks course in history would cover an equal length of time. He suggested that this difficulty was created by allowing the teachers of graduate students to establish the courses available for undergraduates and he advised the pharmacists that they should determine how much time in their four year curriculum should be devoted to history and then put in that course only those things which they would not dare let a pharmacist escape from their institution without knowing.

I believe President Hatcher has expressed the fundamental demand upon all contemporary undergraduate curricula.

National Science Foundation Appoints Paul E. Klopsteg as Associate Director

Dr. Paul E. Klopsteg, Assistant Director for Mathematical, Physical and Engineering Sciences of the National Science Foundation, has been appointed to the new position of Associate Director of the Foundation. Dr. Raymond J. Seeger, program director for physical sciences, has been appointed acting Assistant Director for Mathematical, Physical and Engineering Sciences.

In his new capacity, Dr. Klopsteg will be responsible for assisting the Director and the Deputy Director of the Foundation in following closely the development of relationships with universities and with other Federal agencies; he will also handle special assignments of importance to the scientific programs of the National Science Foundation. Dr. Klopsteg, who came to the Foundation in November 1951, was Professor of Applied Science and Director of Research of the Northwestern Technological Institute, Evanston, Illinois, and is on leave of absence from Northwestern.

What Are the Contemporary Demands on Engineering Curricula?

Mining and Metallurgical Engineering

By C. L. WILSON

Dean of Missouri School of Mines

At the turn of the century the education of the mining engineer was considered to have reached its highest level when the student went to the Bergakademie in Freiberg, Germany, the Royal School of Mines in London, or L'Ecole des Mines in Paris. The School of Mines of Columbia University was the first division of a university in the United States established specifically as a School of Mines. It was officially opened on November 15, 1864. Other Schools of Mines were established in Missouri, Colorado, Michigan, South Dakota, Montana, and New Mexico on separate campuses. Mining Engineering curricula and the B.S. degree in Mining Enginering were offered at numerous universities throughout the country during the latter quarter of the 19th century and the first part of the 20th century. At mid-century the trend has changed and now students from many countries come to the United States for instruction in mining. Universities in Canada, too, offer instruction in mining which is as excellent as that of the United States or any other country.

Previous to 1920 curricula in Mining Engineering covered the entire field of what is known today as the mineral industries. A student graduating in Mining Engineering would just about as commonly go to a smelter as to a mine. His work in mining would include geological exploration as well as mining exploitation. At a smelter he might start as an analytical chemist or assayer and then advance to either smelting or concentrating operations. His curriculum in Mining Engineering had prepared him more or less adequately for any of these fields of work. The mining engineer, because of the probability of going to remote sections of this country and to many foreign countries, had to have some knowledge of surveying and Civil Engineering, Mechanical Engineering, especially steam power, and some Electrical Engineering as well as Chemistry, Mineralogy and Geology. Good Mining Engineering curricula, even before the beginning of the century, contained courses in Mechanics, Hydraulics, Thermodynamics, and Steam Power. Fundamental courses such as Mathematics, Physics, Chemistry and Drawing were taught in the first two years.

While the Mining Engineering curriculum, up to about World War I, was considered adequate for the smelting or extractive metallurgist, the importance of physical metallurgy began to grow so rapidly following World War I that specialization was introduced and curricula and degrees in Metallurgical Engineering were offered in many schools and colleges. The primary distinction was that the Mining Engineering curriculum contained more courses in Geology and the Metallurgical Engineering curriculum more courses in Physics and Chemistry. The growth of the petroleum industry resulted in curricula in Petroleum Engineering and the importance of the geologist brought about curricula in Geological Engineering.

With the depletion of high grade ores, the art of mineral dressing became a necessity and while mineral dressing is rarely a separate curriculum in our colleges today, it is a respected option or branch of Metallurgical Engineering. One more field should be mentioned and that is Ceramics or Ceramic Engineering which is the application of scientific principles to the manufacture of products like brick, glass and porcelain from nonmetallic minerals usually at high temperatures. Ceramics is one of the oldest arts known to man.

Advances in Technology

From the preceding evolution it can be seen that before 1920 Mining Engineering prepared the student, with a remarkable degree of success, to apply his education to engineering activities in mining, metallurgy, geology, mineral dressing and ceramics. In the last quarter century new discoveries and applications of fundamental sciences have resulted in miraculous advances in technology and these advances, together with the pressure of competition requiring low cost production, have compelled industry to seek engineers with more specialized training. While mineral industries today generally require the services of mechanical engineers, electrical engineers, and civil (structural) engineers in their fundamental operations, they need engineers who are trained in specialized areas of what now is frequently given the comprehensive appellation mineral engineering.

The mining engineer today deals primarily with the selection and design of mining methods and the proper equipment for mining exploitation. His work demands a knowledge of structural geology and map interpretation. He must be acquainted with the principles of prospecting and mine development. Succesful underground mine development requires ventilation and atmospheric control as well as blasting, timbering, transportation and hoisting. Operations will not be successful unless principles of cost evaluation and management are correctly applied.

Metallurgical Engineering deals fundamentally with the extraction of metals from their ores and shaping them for utilization. This field itself has become highly specialized although fortunately not with separate academic degrees or even options. The curicula however are arranged with electives so that the student may specialize in mineral dressing, extractive metallurgy, or physical metallurgy. Mineral dressing deals with the mechanical separation and concentration of the valuable minerals from those not presently desired. One important type of mineral dressing known as flotation has made such intelligent application of the principals of physical, organic and colloid chemistry that good curricula now contain courses in all of these fundamental subjects. Extractive metallurgy deals mainly with smelting or leaching and these operations require fundamental courses in chemical thermodynamics and electrochemistry. Physical metallurgy is a study of the structure and constitution of metals and alloys and their relation to their physical, chemical and mechanical properties. One of the most important fields of knowledge needed in this branch is the physics of the solid state. Because metals are relatively simple in their atomic structure, physical metallurgy has contributed much toward the knowledge of the physics of the solid state. Courses in x-ray analysis are becoming essential. The electron microscope and the x-ray spectrograph equipped even with Geiger counter are tools which illustrate how physical metallurgy is dependent upon basic modern science.

Petroleum engineering has likewise been subdivided into two distinct fields—petroleum production and petroleum refining. Petroleum refining is essentially a specialized field of chemical engineering. Petroleum production differs from mining engineering in that the end product is a liquid or gas instead of a solid and therefore quite different exploration and exploitation methods are required. The geology used in Petroleum Engineering must include not only structural geology

and stratigraphy but also paleontology and even micropaleontology. The science of geophysics finds widespread application in prospecting for oil and training in geophysics is becoming a requirement in Petroleum Engineering curricula. All of the above curricula are offspring of the original curriculum in Mining Engineering. The above curricula, where accredited by ECPD, may be assumed to conform to at least the minimum qualitative and quantitative criteria set forth by ECPD. They prepare engineers for the mineral industry which, like agriculture, is a basic industry upon which our present civilization is founded.

Demands Becoming Greater

The demands upon the mineral industry will become greater in the next half century than ever before. Mineral deposits, unlike agricultural products, cannot be replanted and it is logical to assume that they eventually will be depleted. Substitutes for materials now commonly used must be found. We can here express our confidence in the resourcefulness of youth. For example, my grandfather was constantly concerned about the reckless cutting down of hickory trees. Although a successful business man in his day, he could not imagine a satisfactory substitute for hickory in the manufacture of wagon wheels. Another example is found in the extended use of bromine. For many years the principal and adequate source of bromine was the brine wells of Michigan. When motorists began to demand high test gasoline in larger and larger quantities, the brine wells of Michigan could not supply enough bromine for the manufacture of all the tetraethyl lead required. No other source of bromine appeared available except ocean water. Today engineers are literally mining the ocean for its bromine. Our engineering curricula must continue to inculcate in our students this spirit of experimentation and discovery.

Most of the mineral deposits outcropping on the surface have been discovered by that historical character the prospector on his burro. Today the geologists must explore the earth's crusts to greater depths. Such exploration will require more and more use of complicated scientific apparatus whose utilization will demand an understanding of modern physics. Geology, formerly a descriptive and qualitative study, must now become quantitative to an advanced degree. Methods of mining to greater depths will demand engineering skill far beyond that employed in present day methods. Metallurgical Engineering must cope with the problem of treating lower grade ores and of extracting such more common metals as titanium and zirconium from their minerals and aluminum from clay. In addition of course we must reconcile ourselves to less wasteful and more intelligent use of metals and materials which are now common and we must insure more efficient secondary recovery after their use has been completed.

Firm Foundations in Fundamentals Necessary

Contemporary demands on curricula in mining and metallurgical engineering place upon us the vital responsibility to make it possible for the engineer who graduates today to meet these changing and complex problems twenty-five or more years from today. These demands emphasize the necessity of building firm foundations in the students' knowledge of fundamental scientific and engineering courses. They require a lessening of emphasis upon courses which are largely descriptive in nature. Courses in mining methods, smelting methods, other metallurgical and mineral dressing operations, and ceramic processes must of necessity contain some descriptions of current procedures but these must be reduced to a minimum and more emphasis must be placed upon design, application and experimentation. Such contemporary demands are not difficult to meet because the principal requirements are not college buildings, laboratories and new and ex-

pensive equipment although of course adequate physical plant will always be necessary in modern engineering colleges. The principal requirement is the teacher himself who can skillfully guide the student toward that only kind of successful education which is self education. The teacher must guide the student to sources of knowledge and then inspire him with confidence and enthusiasm. Attendance at meetings of engineering and scientific societies, and particularly at meetings of the American Society for Engineering Education, will provide the teacher himself with good guidance. By affiliation and active participation in local, sectional, and annual meetings the teacher will make it possible for ASEE to help them meet the contemporary demands on engineering curricula.

Learning or Teaching Aids?

In the September issue of the Journal of Engineering Education the Committee on Teaching Aids issued a last call for devices to be submitted for review and possible inclusion in the forthcoming CATALOGUE OF TEACHING AIDS. A similar appeal has been made in the past to industry through important technical periodicals.

The material submitted to the Committee as a result of these pleas indicates that a wealth of high caliber devices and ideas are available from engineering college teaching staffs. It has also led to the conclusion that such devices can be classified and defined as follows:

1. LEARNING AID—A device that creates within the student a desire to recognize or pose a problem and which further enables him to understand the fundamentals underlying the solution.
2. TEACHING AID—A device that aids or effects the explanation of rather narrow areas of factual knowledge. The Committee is reviewing both types.

It has been made painfully clear to the reviewing groups in civil, electrical, mechanical, mechanics and mathematics that the colleges are the most fertile source of LEARNING AIDS. Unfortunately, engineering teachers appear to be extremely modest in offering devices for consideration by the reviewing committees. It is regretable that a personal contact cannot be made for all such devices but the committee must rely on the help of all ASEE members in ferretting out this material. The deadline is March 1. May we have your continued help?

Carl W. Muhlenbruch, Chairman
ASEE Committee on Teaching Aids
Northwestern Technological Institute
Evanston, Illinois

Orientation and Development of Junior Engineers*

By JOHN F. GORDON

Vice-President of General Motors Corporation

I am honored that your societies have invited me to come here tonight to speak upon the subject "Orientation and Development of Junior Engineers." With your permission, I would like to deviate slightly at times with some remarks of a more general nature because I feel that you may be more interested in objectives than in methods.

In General Motors, we regard engineering as a career of unparalleled opportunity for the young man leaving a technical college. It is a career of challenging assignments, of interesting problems, of pleasant working conditions. There is really no limitation on progress or financial compensation as evidenced by the fact that the Chairman of the Board of Directors, the President and about half of the Vice-Presidents also started their careers as engineers. They have progressed through the organization as Civil, Electrical or Mechanical Engineers into their present executive positions. Moving a little lower on the scale of corporation authority shows a remarkably high percentage of engineers in positions of great responsibility in the divisions as general managers, works managers, chief engineers, and plant managers. These facts assume even greater significance when it is realized that graduate engineers represent less than two percent of the employees and all of our men classified as engineering employees do not add up to five percent of the total.

There is no specific procedure in promotion which makes it particularly easy for the engineer to achieve such status. On the contrary, the promotion into important executive positions of engineering personnel is considered one of the major reasons contributing to the phenomenal growth of General Motors during the past twenty-five years, when product sales have been multiplied over seven times, net income increased three times and employees increased from 130,000 to 469,000.

We believe the results achieved in the corporation emphasize beyond any words that I might say tonight how importantly the various types of engineering science have contributed in men and products to the growth of one of the nation's great business enterprises.

We approach the future with confidence that the same form of progress will continue on an accelerated basis because the percentage of engineering personnel to other employees should continue to increase and show a correspondingly greater contribution to our corporate success. With this psychology in mind, it is only natural that we approach the employment and development of junior engineers with a complete realization of their potential worth to our future programs, even though we know that the true value of their training may require ten to twenty years for development into full significance. Today we hear a great deal about the shortage of engineers, and every effort is being made to attract graduates to in-

* Presented before the Engineers' Council for Professional Development in Chicago on Friday, September 5, 1952, in connection with the Centennial of Engineering.

dustrial employment. At the same time, much is being done to stimulate interest in the study of engineering among a larger number of high school students. Industrially, we are redoubling our efforts to make better use of experienced engineers to their full abilities by effectively using the engineers who are available and by filling the more routine type of technical positions with people having a limited background of training.

We know that a fair sized percentage of those who start the study of engineering do not finish. Some drop out for financial reasons; some are attracted by jobs offered to them before they graduate and some find they do not have sufficient interest or the necessary ability to continue this training. Some of these change their courses to other fields, such as business administration. I do not believe we should worry about this as a by-product of efforts to attract more high school graduates into the study of engineering, because a good percentage of such students will have gone far enough in their studies to learn the fundamentals of the engineering approach to problems and will find employment in which they can make valuable contributions. From a long range standpoint we need graduate engineers who can handle the problems of product design and development but we also need those who can apply the engineering approach to the problems of production, business administration, sales and human relations, even though they may not be graduate engineers.

Employment of Engineering Graduates

While I am talking about the present shortage of engineering talent, I think it is desirable to explain our method of determining the number of college graduates we need to employ each year. This is important in its effect on our program of development for these men after they reach employee status inasmuch as we desire neither too many nor too few in the organization. Too many can easily result in injustice to the employees promotion rate; too few can only result in inadequate rate of progress for the company. Each separate division and corporation staff activity is requested to analyze its fields of work and the demonstrated educational requirements for success in those fields in order to determine the educational courses from which graduates should be recruited. The field of engineering education comprised 86% of the group requested for recruitment in 1952. Consideration is also given to such other factors as retirements, normal turnover, and possible growth or expansion of the organization in arriving at the probable number of future opportunities in the various departments of the business. Also taken into account are such factors as the number of our own General Motors Institute students in training, those available for promotion from other non-collegiate personnel, and the average number of graduates who drop out during their first few years of employment. From the study of these statistical analyses, each division determines the number of new graduates to be employed. As a general guide it is suggested that each unit employ at least one graduate per year for each one thousand employees.

A similar approach is used in the determination of the number of General Motors Institute students to be sponsored by each division or staff group. In this instance the sponsoring unit must not only take into account a possible loss in graduates during their first years of employment after graduation but also some loss in students during the four or five years of collegiate training prior to graduation.

The Institute became a part of General Motors in 1924 and is now the focal point of our training activities for the entire corporation. The most important segments of its activities are the cooperative collegiate programs in mechanical engineering, industrial engineering and business administration. These programs were established because it was felt that a portion of the engineering talent needed by the corporation could be found among our own employees and effectively

trained in our own operations—particularly in the fields of automotive design and manufacturing. We have evolved a balanced program of training at the collegiate level within the organization and recruitment of graduates from other colleges whereby we capitalize to the maximum on our internal "know-how" but maintain full access to the variety of viewpoints and educational backgrounds developed at other colleges across the land. We feel justified in claiming that the program results in an industrial team of unusual strength and ability in both theory and practice.

For example, in arriving at its quota of Institute students for its engineering department in 1950–51, a typical division of General Motors, made the following analysis:

Needs:

Number of exempt personnel in the department	50
Number of yearly losses plus number needed for expansion	3
Number of new graduates needed each year	3

Sources:

Number to be promoted from non-collegiate ranks	0
Number to be recruited from colleges	2
Number of G.M. Institute graduates needed	1

After adjusting for a possible student and graduate loss it was estimated that the number of G.M.I. students would be two per year. A similar analysis was made for each of the other departments and the division arrived at a figure of 14 Institute students in engineering and business administration needed each year in addition to 8 graduates from other colleges.

We believe this is a factual and realistic approach to the troublesome problem of arriving at the number of graduates needed in our industry. It gives primary emphasis to the places where there are opportunities. It reduces over-recruitment. It is fair to employer and employee alike.

You may be interested in the following comparison between the number of General Motors Institute and other engineering graduates employed during the last four years:

Year	G.M.I.	Other Engineering College Graduates
1948	242	171
1949	350	282
1950	301	275
1951	200	339
4 year totals	1093	1067

You will note that we have averaged something over 500 new graduate hires per year for these four years with as many as 632 entering our organization in a single year. Each of those men was employed with full expectation that the opportunity for a career awaited him in the corporation, if he could demonstrate the ability to justify that career. The integration of such a group would be a major problem if it were attempted on a centralized basis, but it is not accomplished that way. With the decentralization of operations which is the keystone of our management policy, the orientation and development program is in the hands of divisional management at Chevrolet or Cadillac, at Electromotive or Delco-Remy, or one of the many other divisions doing business under the General Motors banner. As is true in all other phases of our business, however, the individual divisions expect and receive direction and advice from the central office staff, executives, and the Personnel Policy Committee of the corporation to assist them in their program with college graduates. This advice is not based on the premise that college graduates should be established as a separate group nor given preferential treatment. Like all other employees, it is the graduate's responsibility to develop himself, prove his worth and show whatever potential he has for greater responsibility.

Emphasize Need for Competent Engineering

In General Motors we recognize that the operating success of the corporation

depends primarily upon a continuous program of development and improvement in the major elements of facilities, products, and personnel. It goes without saying that improvements in our facilities and products require an extensive program of research and development under the guidance of engineers and scientists. Each change in plant layout, each improvement in manufacturing methods, each revision in equipment involves engineering problems. Almost every phase of the business except sales and legal guidance emphasizes the need for competent engineering.

We also recognize that the young engineers we employ come to us with a good fundamental understanding of engineering theory and some background in its application. In a sense they are the partially processed personnel material out of which will come many of our ranking engineers and executives of the future. Thus it is our responsibility to establish procedures which will assist the graduate in his introduction to industrial employment and at the same time maintain him in an environment which will stimulate and promote his growth. Provided with these helps, it is still required of the individual employee that he take the initiative in self-development through use of the opportunities that are presented to him.

In meeting the requirements I have outlined, the majority of our operating divisions have set up orientation training programs for the college graduates on their rolls. While these programs are tailored in content and length to match the situations in different divisions, generally they are designed to acquaint the new employee with the products and practices of the plant, give him a brief acquaintanceship with the work of its principal departments, and help him to learn what is expected of him in an industrial position by observation of the work of other engineers in the organization. These programs usually consist of a series of practical work assignments in the departments or sections of the Divisions related to the field of work for which the graduate was employed. For example, a junior engineer might be given brief assignments for observation in manufacturing, production engineering, accounting, sales, traffic and purchasing in addition to his major work assignments in product design and development. This gives him a limited amount of information about the business, but primarily helps him to understand the interrelation of engineering activities with other activities in the organization. It is also helpful to employee and management in proper placement of the new man in his first post-training work assignment.

Professional Development Encouraged

An essential element of all in-plant training programs is frequent contact between executives of the management group and the trainees, as this provides the opportunity for our young engineers to acquire some of the practical knowledge that these older men have accumulated during their years in the division. Even more important in our opinion—it helps the youngster to know that his efforts are being recognized, that his capabilities are being evaluated, and his professional code is being improved by these contacts. We try to impress upon the young engineer the fact that his technical educational opportunities did not end when he received his degree. He is urged to participate in the meetings of local technical societies, in community affairs and plant activities of various kinds, always with the objective of his personal and professional development through the medium of his own activities.

Even the most talented group of young engineers would be at a loss if we did not provide them with the physical facilities needed in their professional efforts. We are justly proud of the excellent buildings and equipment in use by our divisional engineering departments. From them have come many of the major improvements of modern transportation, such as the high compression engines, the light weight two cycle diesel engines, automatic transmissions, all steel bodies, ethyl

gasoline, diesel locomotives and jet engines. Our research laboratories and product proving grounds have been of invaluable assistance to the chemists, metallurgists and engineers with the ability to study and evaluate some of the fundamental factors of combustion, lubrication and power development.

Yet, we are not satisfied. Construction work is now in progress, as it has been for three years, on a new Technical Center on the outskirts of Detroit. When completed, it will house staff activities in research, engineering, styling and process development in a group of buildings that provide an entirely new concept of industrial research to meet tomorrow's needs. Our young engineers are well supplied with facilities which will aid them in making professional progress, and will be even more adequately supplied in future years.

I have spent some time in discussing the technical phases of our development program for young engineers with full knowledge that any orientation program aimed only at engineering competence would be inadequate. Consequently, I would like to direct attention to the "human engineering" factors in the same program and thus leave with you some of the psychology of General Motors in dealing with its employees.

It should be obvious that any large corporation is an organization of many people in which no single individual is apt to reach his personal objective without the voluntary cooperation and assistance of his associates. Experience has demonstrated many times that the degree of cooperation is determined by the personality factor more than anything else. Modern industrial progress depends on teamwork to such a degree that the graduate must be able to submerge his individuality to a considerable extent in order to become an effective member of that team. As a member of the team, he must be capable of making his own contributions, yet be flexible enough to change his own ideas as new thoughts are presented to him by other members of the group. Few indeed are the industrial positions wherein an engineer can work as a "lone wolf." If he honestly wishes to progress, he must be able to adapt himself to the organization in a whole-hearted manner. He must learn to work with people until his responsibilities increase to such an extent that the major requirement is for people to work with him.

Personality Development

Much of the executive effort going into our development program aims at the goal of influencing and correcting personality and professional characteristics which, if left unchecked, could and probably would have an adverse influence on the individual's future progress in the organization. This is a difficult task but the results justify a great deal of effort.

Actually, we believe that the essential components of a successful career in our corporation can be reduced to just three requirements on the part of the young graduate engineer:

(1) The graduate's native abilities such as health, energy, imagination, intelligence, initiative and comparable characteristics.
(2) The graduate's ability to understand and use the known laws of the arts and sciences—as you have taught him to do in his formal education.
(3) The graduate's understanding and appreciation for the so-called "unwritten laws" of the practice of engineering by which his own efforts are integrated into the larger field of industrial production.

Believing as we do regarding the essential components of a successful career, our "human engineering orientation" attempts to assist the development of each of these components within the limits of our abilities. We recognize our limitations in seeking much improvement in native abilities except as we utilize existing qualities to their best advantage. However, the requirement of high level native ability is sufficiently important that

we give it careful consideration in the selection of our students at General Motors Institute and in the screening prior to recruitment of all other college graduates. Perhaps I should say that we value above average physical and mental characteristics in combination with professional ability very highly, and make every effort to determine, in advance, that our new engineers will have an abundance of native ability before they enter the corporation as engineering employees.

With reference to the second requirement for success—the graduate's ability to understand and use the known laws of the arts and sciences—we have no quarrel with existing formal education in technical colleges. The graduates who join us each year are well instructed in the fundamentals of theory but lack background in its application except to a very limited extent. This feeling is engendered to a large degree by our extensive experience in cooperative educational programs involving thousands of men in our organization. We place a high value on the extensive background experience gained by cooperative students during their years as undergraduates, and would like to suggest greater efforts on the part of colleges to secure comparable opportunities for their students through summer employment or similar industrial contacts.

It would be relatively easy to speak at great length on the third requirement for success which covers the unwritten laws or the professional code of engineering practice and behavior because I am very familiar with the subject. It is only in the last few years that I have not been devoting all of my time to the practice of engineering. I mention these years of professional experience in order to place proper emphasis on this statement—very few of the many engineers that I have known, failed to progress due to insufficient technical ability. Many have been found lacking in personality or personal characteristics and their lack of development classed as a professional failure. The price of these failures is large at any time, but it grows greater when the man is allowed to move along in the organization for some time before his shortcomings are evident. We try to avoid such mistakes throughout our development program by frequent appraisal of each individual in the program by expert counseling aimed at correction and by continuous association with experienced engineers. If all of these methods fail to produce the desired results, there is always the possibility of transfer into other activities of lesser requirements.

My talk has covered some of the things we believe are important in providing opportunity for *self development* to the engineers in General Motors. This concept of an individual "developing himself" as opposed to "being developed" by the company recognizes that no one is foreordained to become an executive although we strive to achieve that result over a period of years.

Cooperation with College Faculty Sought

We aspire to a closer relationship and a better understanding between college faculty members and the men of our industry who have responsibility for carrying out the program I have just outlined. To achieve this result in General Motors we are giving added emphasis to our educational relations activities with engineering colleges. This program provides for periodic conferences of technical educators with our engineers in order that we can become better acquainted and develop a more complete understanding of our mutual aims. We are preparing to furnish qualified industrial speakers on engineering topics and to the use of other media for making available engineering and manufacturing data which is suitable for supplementary use by colleges. We are studying ways and means of providing some of our products for instructional and testing purposes in the schools. We are interested in every possible improvement in our program to make it successful and practical because we place great faith in the ability of these young men to assume responsibility for a large part of the engineering, industrial and economic leadership of tomorrow.

Can Engineering Graduates Man a Company?

By E. G. BAILEY

Chairman of the Board, Bailey Meter Company

My answer to the question, "Can engineering graduates man a company?" is yes, because they are now doing it very creditably in many cases. The important point is: How can each one of us study the many cases at hand and draw some helpful conclusions regarding college curricula, selection of graduates, training, and promotion of engineers for the best interests of our industrial economy?

The success of a company is usually measured by its usefulness to mankind, its rate of growth, and its earnings. A good record in these respects is usually the result of team work on the part of management to evaluate properly the needs in a given field of products or services, and to accomplish results through invention, development, production methods, sales, services, and finance.

The August 30 issue of *Business Week* gives some interesting data regarding ten companies which show a marked contrast from the average of industry generally over the same period. Eight of these ten companies show an average increase in invested capital of 42 per cent per year from 1929 to 1951, while the invested capital of industry generally increased at the rate of 2.8 per cent per year over the same period.

The net profits of the eight companies averaged 11.2 per cent of invested capital in 1929 and 9.6 per cent of the increased capital of 1951. Some of these data are given in the accompanying table. It would be interesting to study the management policies of these companies with respect to our topic.

Statistics alone are sometimes misleading. During a depression the earnings and growth may be poor even though the management is good. Contrariwise, during an inflationary "easy prosperity" like the present, very poor management of a company may not be evident, even to the stockholder.

Now, let us review some average statistical data from the Engineers Joint Council survey of 1946 on "Employer Practice Regarding Engineering Graduates." In this summary 125 companies, with a total of 2,020,000 total employees, reported 38,000 engineers employed. This is 1.8 per cent of the total number of employees, or one engineer for each 55 employees. In some industries the engineers were 6 per cent of all employees and in others as low as 0.3 per cent. In some groups the engineer executives comprised 50 per cent of all executives of the same rank, and in others as low as 13 per cent with an average of 28 per cent. The anticipated increased need of engineers was 6 per cent per year of the engineers then employed, or one engineer for each 1000 employees.

From this survey a median of the 14 companies within the machinery group has been selected to represent a typically average industrial company. This we shall call "X-Machine Company," employing a total of 7000 people and having gross sales of about $80,000,000 per year. This is a fairly representative figure of about $12,000 output per employee.

This company employs 133 engineers, 28 of whom, which is 21 per cent, are in executive and top management positions. The total number of executives and upper managers is 64, of whom 44 per cent are engineers.

This industry group said they needed 8 per cent additional engineers per year, or, for "X-Machine Company," 11 engineering graduates each year, or 1½ engineers per 1000 employees.

DATA FROM *Business Week*
August 30, 1952
(page 58)

	Invested Capital				Net Profits	
			Average Increase per Year			
	Millions of Dollars			Per Cent of 1929	Millions of Dollars	
	1929	1951			1929	1951
Abbott Laboratories	3.6	67.9	2.9	81.	0.6	10.4
Aluminum, Ltd.	50.2	443.5	17.8	36.	2.4	28.8
American Cyanamid	41.3	274.9	10.6	25.	2.3.	34.8
B. F. Goodrich	162.6	239.8	3.5	2.	7.4	34.7
Humble Oil	216.4	916.5	31.9	15.	32.5	109.5
International Business Machines	33.7	318.3	12.9	38.	7.4	27.9
Minneapolis-Honeywell	4.9	80.0	3.4	70.	1.4	9.3
Minnesota Mining	4.8	106.6	4.6	96.	1.5	9.9
Monsanto Chemical	12.3	263.4	11.4	93.	1.1	23.5
Scott Paper	6.7	67.2	2.7	41.	0.9	10.9
Total	536.5	2778.1	101.8	19.	57.5	299.7
Per cent of invested capital					10.7	10.8
Total with omission of B. F. Goodrich and Humble Oil	157.5	1621.8	66.4	42.2	17.6	155.5
Per cent of invested capital					11.2	9.6

High Percentage of Engineers Desirable

In my opinion, a company in this kind of engineering business should have about 80 per cent of its executives with engineering training. The reason for this is that an engineering education is eminently helpful as a background for factual approach to the problems encountered in industry, based upon engineering processes, products, and services. Many companies do not now have this high percentage of engineering graduates but they should gradually build up to a higher and more adequate proportion.

Whether a company is increasing its proportion of engineers or continuing on a normal basis, it should employ a certain number of new graduates each year. I mean each and every year whether business is good or bad. One of the mistakes which many companies make is to take on fewer graduates when times are a little slack. This leaves a gap in the supply of properly trained men a few years later when they will need more men than they will then have. For instance, we all short-changed the engineering graduates during the depression of the thirties, and subsequently we needed them badly during World War II. In 1949 all of the available engineering graduates were not given proper jobs and, as a result, a shortage is being experienced today.

Hiring the proper quota of new graduates is not enough. They should be enrolled in proper training courses and given every opportunity to learn the business and develop into positions of responsibility and leadership. To help industry do a better job in such training is the purpose of Mr. Montieth's activities in ECPD during the past few years.

I will not go into detail regarding the training course itself but I would like to express some opinions about the problems of the later advancement of these trained

engineers through the upper echelons of the company.

Engineering graduates, while they have received the correct basic engineering training, are human beings with differences in temperaments and abilities in both technical and administrative fields. To successfully man a company with engineers requires considerable development of the men over and above what they are when they receive their diplomas.

The usual organization chart is drawn to show the line of authority running down from the top. It should also be looked upon as the path for advancement from the bottom upward toward the top position of president.

Upon completion of the training course, the engineer is usually assigned to a department in a particular division and then, for a time at least, left to the mercy of whomever happens to be his immediate boss.

I think the education department should have a continuing interest with some cooperative authority to make sure that the individual is treated fairly with reasonable assurance that his advancement will be the greatest of which he is capable.

At some point in this upward progress, each man should become known personally to the top management so that he will be properly evaluated and given every possible chance for deserved promotion insofar as justified by relative competitive abilities.

Engineers for Top Jobs

Now a word about engineers for top jobs in comparison with men trained in the legal, financial, or "business administration" fields.

The top executives should form a strong team, proficient in finance, sales, production, and especially in engineering, research and development, and invention. Each and every one should know the product in every detail, and especially from the customers' viewpoint.

The customer is all-important and a full knowledge of his needs and future trends should be known not only by the sales department but also by the production and engineering departments, and especially by the president. As the products and services of industry are largely within the engineering field, it is best that all members of this management team should be engineers or men with an engineering background who have advanced on their own initiative into fields of finance, sales, and management.

Some lawyers and bankers have become very engineering minded and have used good judgment in making major decisions regarding engineering, research, and development problems when they have confidence in and give opportunities to the engineers in the team to analyze and evaluate the problems properly.

The degree of success of a company rests almost solely with the president or top executive officer. It is he who selects the vice presidents and top staff and establishes the policies and methods for coordinating the different divisions and departments.

Many of the most successful companies, large, small, and intermediate in size, have done very well in the training and advancement of engineering graduates throughout their organizations up to and including the presidency.

Those that have not done so well in this respect simply do not grow and prosper. They either limp along, or fail, or are absorbed by others. When a successful company makes some changes that are not for the best, it may be several years before the mistakes are fully realized, because a going concern can drift for some time upon the reputation and momentum of the past.

Many of us can relate cases where improvements should be made, but it is best to study factual data of successful companies for the benefit of all. The engineering profession should present to the top executives of American Industry illustrative factual data relating to the successful use of engineers in such an effective manner that all will strive to improve their present methods for selecting, training, and advancing engineering graduates within their respective companies.

Manpower Utilization and National Security*

By ARTHUR S. ADAMS
President, American Council on Education

The steadily increasing demand for trained personnel by the military services and by the productive economy of the country emphasizes the urgency of the need for finding effective and equitable solutions to the problems of manpower utilization which Mr. Brown has identified so clearly.

In dealing with these problems, however, our concern with total overall allocation of manpower should not blind us to the overriding importance of the attitudes, concerns and interests of the individuals who comprise that total.

The principle that each of us has an obligation to serve our country is certainly the fundamental basis of our free democracy. Indeed, we need to recognize more clearly than we now seem to do that we, each of us, can expect to continue to enjoy the blessings of liberty only in the measure that we accept the commensurate and personal responsibility which freedom so surely entails.

Likewise, there can be no dispute on the principle that each person should serve where he can serve best, in the light of his abilities and limitations, his talents and his training and that such service should be up to the full potential of his capacity.

Yet in all of these considerations, as we give attention to the maximum contribution of each individual, we should—indeed we must—recognize the aggregate of contributions of all individuals in relation to the total needs of the country. Our build-up in military strength in which science and engineering play such vital roles is assuredly of great importance, but I believe we can all agree that it is only a part of our total national problem. Of equal importance are our efforts to develop connections of mutual understanding and support with the other nations of the world.

Perhaps our most powerful weapon is our effort to provide full access to the facts about our way of life rather than to ring down an Iron Curtain between ourselves and other nations. In this effort to promote understanding between other nations and ourselves, men and women trained in the social sciences and the humanities have vital and significant parts to play. The fact that they have these parts to play does not in the least minimize the essentiality of the contributions to be made by engineers and the scientists. We need skilled people in all of the disciplines. We must recognize that there is a shortage of manpower and womanpower for *all* of these necessary activities.

In a speech in this city last spring, Mr. Robert L. Clark, Director of the Office of Human Resources, of the National Security Resources Board, made this point with particular effectiveness by detailing the current scarcities for earth-scientists, geologists, geophysicists, meteorologists, oceanographers, geographers, soil-conservationists and agronomists, and then went on to make the significant point that while "adequate military manpower plus scientific, technological, and managerial supremacy will give us maximum military strength, it must be borne in mind that military force has the ultimate object of achieving a change of behavior of an enemy only after reasonable means of persuasion have

* A statement by the Engineering Manpower Commission of Engineers Joint Council.

failed." As he put it "an intelligent view of our national security requires that we have the same kind of concern with the characteristics and behavior of people in all parts of the globe that we so obviously have with the characteristics and behavior of matter."

To achieve an understanding knowledge of other people requires clearly that we have an adequate supply of people who are expert in all of the factors of life of those people. Certainly we should know as much as possible about our principal adversary, Russia. Yet in the last four years only thirteen Americans have taken Ph.D. degrees in Russian language according to the reports of the U. S. Office of Education. It seems abundantly clear to me that in framing our overall manpower policy, we must take account not only of the obvious needs of technology and science but of the equally impressive, although not so obvious, needs in other areas of knowledge.

It was on the basis of this sort of thought that the present Selective Service policy concerning college deferments was based. In these days when, as Dorothy Thompson has said, "man's means of communication so far outstrips his ability to communicate" we must take provident action to be sure that we have qualified people in as great a number as possible in all of the departments and subjects of human knowledge. We cannot be sure but that at some future time, it may be vital to our security to have the specialized knowledge of some few individuals who like the specialists in coral formation in World War II were able to do so much to push forward the campaign in the Pacific. To put it another way, we can never be sure that some type of specialized skill, not now considered especially important, may become critical in meeting a national need. Who would have argued in 1929, when Dr. E. O. Lawrence started his researches with the cyclotron at the University of California, that a nuclear scientist would be essential to our military defense in 1952?

Concept of the Individual is Important

In meeting these total needs I believe that we are sometimes blinded to the importance of individual hopes and aspirations by the sheer weight of numbers with which we have become concerned. We get to thinking of people as units with vocational tags attached. It is one thing to talk about the need for twenty, thirty or forty thousand engineers; it is quite another to think about one young man who wants to become an engineer. I feel that we must constantly keep in mind that we are dealing with individual people and that what they want to do in order to make their contribution is important.

As a person trained in engineering and also as one who has participated in both World Wars I and II, I cannot subscribe to the notion that a plan for compulsory exemption from service for any group is in the national interest. In my opinion, it is not even in the interest of that group no matter how important the services of those who form the group may be toward meeting our total need. For example, to refuse enrollment in the Reserve Officers Training Corps of scientific and engineering students would seem to me to be an invasion of the individual's freedom of action as a citizen. Now at the same time, I would hasten to say that if such an individual did enroll in the R.O.T.C. and subsequently entered upon active duty it would be only common sense for the military service of which he was a part to do its utmost to make full use of his special talents in assigning him to duty in which those talents could be fully used.

One further item on the R.O.T.C. to which Mr. Brown alluded. Both the Army and the Air Force are undertaking during the coming year experimental curriculum revisions by which branch and special designations for various components in the R.O.T.C. will be abandoned in favor of a general curriculum. Some of those especially interested in our current engineering shortage have expressed concern that this move will militate against the most effective assignment of these young men when they graduate insofar as utiliz-

ing their special training is concerned. In my opinion, this concern is not justified. I am informed by responsible officials of the Department of Defense that it is precisely to make better use of the individual's professional training that the change is being made.

In many of our institutions we have had units of the R.O.T.C. in, let us say, field artillery, coast artillery, infantry or other branches which offered the only opportunities for the enrollment of engineering students in the R.O.T.C. Once commissioned in a particular branch, a young R.O.T.C. officer found it difficult to transfer to a branch of the service to which his professional training was more germane. In the new plan each graduate of the R.O.T.C. will have an opportunity to indicate a preference for that branch of the service which he desires and for which he is best qualified. Moreover, it is my understanding that careful procedures are in prospect by which his indication of his preference will be reviewed by those competent to appraise his professional qualifications. It would therefore appear that the move of the Army and the Air Force to a general curriculum is a move in the direction of the better utilization of this individual's strength which I think we will all agree will lessen our present concerns with waste of engineering talent in the military service.

Supply of Engineering Graduates

It is interesting to me, and I hope it is to you, that on December 30, 1947, I participated in a symposium in this city at the annual meeting of the American Association for the Advancement of Science which had for its subject "Insuring Adequate Scientific Personnel." At that meeting it was reported by others that there was likely to be an over-supply of engineers by 1950 with certain engineering specialities having a much greater over-supply than others. It was further reported that the immediate attempt to train more scientists might do more harm than good because in the long run there is a danger of shortage of high quality scientists because of the then current over-crowded conditions in colleges and universities.

In my remarks at that symposium I offered an exactly contrary opinion. It seemed to me then as it does to me now that while it may be theoretically desirable from the standpoint of utilization of manpower to have the number of jobs exactly match the number of people trained for them, I considered it fortunate that changing conditions make precise planning in this area impossible. I see grave limitations in an education so restricted in outlook that it would provide adequate basis for only one type of occupation. "It seems to me axiomatic that education to be worthy of the name must do much more than to fit a person for a particular vocational slot in the social system. Our objective should be to determine and then to develop to the fullest possible extent the capacity and aptitudes of individual students. Unless the individual has greater resources than those demanded by any specific job he may undertake he lacks that adaptability to changing circumstances which is not merely the hallmark of the educated man but the margin of flexibility which permits our democratic society to progress."

Engineers Play Vital Role in Our Society

Today we know that the predictions of December 30, 1947 about an over-supply of engineers were incorrect. We do need more engineers and we need good engineers. The Engineering Manpower Commission is to be commended for its efforts to attract into the engineering profession young men and women qualified to profit from this type of education. This is indeed an important matter which is contributing with notable significance to a better appreciation by the American people of the vital role that engineers have in our society. In order that this appreciation may develop into a true public understanding there must be confidence that the case for engineering takes into account our total national needs together with full recognition of the importance of the individual.

Manpower Utilization and National Security *

A Statement by the Engineering Manpower Commission of Engineers Joint Council

By CAREY H. BROWN

Chairman, EJC Engineering Manpower Commission. Member ASME

Every citizen shares the universal obligation to serve his country. The type of service he can best render depends upon his abilities and limitations, his talents and training. For the best interests of the nation, each person should serve where he can serve best and up to the limit of his abilities and capacity. This concept demands service, not only in uniform, but also in those activities that must be maintained to support the national economy. Such activities include agriculture, defense, and other essential production, transportation, communications, medicine, education, government, and others, required in the national health, safety, and interest.

Today our nation faces an indefinite period of partial mobilization. In addition to a shortage of manpower within the age brackets considered suitable for military service, the mobilization is further complicated by a dearth of technical and scientific manpower to satisfy the needs of the military forces and of other essential activities. Because of the low birth rate during the depression years of the 1930's, we are faced with a decreasing number of young men reaching age 18 each year. This decrease will continue through 1953 and the trend will not be reversed until 1956.

During frontier days all citizens accepted the necessity of bearing arms to defend their homes. Generally the periods of defensive action were of relatively short duration and the action was local in character. The call to arms caused little interruption of the essential production needs of the community.

Today the situation is different. It cannot be met with the response or philosophy of frontier days. Our essential needs are more complicated and diverse, largely because of the change from an agricultural to an industrial economy and of the higher standard of living which is the product of industrial development. Requirements for defense are likewise far more complicated and diverse. The scene of action is no longer local. The weapons and equipment of the modern fighting man are complex. The development and production of better weapons and equipment requires a higher and higher level of engineering and scientific skills, especially in research and development activities.

We are now far more dependent individually upon the productive efforts of others than were our forebears. We must provide manpower to support the civil economy as well as the military effort. Interruption, or serious reduction, of industrial activities because of a policy which would remove an essential group therefrom to render extended service in uniform, may have grave consequences. It could easily seriously reduce the development and production of the very equipment needed most by our military forces.

Security of this country is not a question of uniformed manpower alone. It

* Presented at the Conrad Hilton Hotel, Chicago, Illinois, September 7, 1952, in connection with the Centennial of Engineering.

is equally a question of ability to produce goods and equipment, not only for the military forces, but also for that part of the civilian economy which is essential to our continued existence. Our potential enemies greatly outnumber us on a man-for-man basis. Study shows that wars are not won by sheer superiority in the numbers of fighting men, or by prewar military training or service alone. They are won through superior equipment and productive capacity.

Germany and Japan provide excellent examples of the effectiveness of superior equipment over preponderance of manpower. In the beginning of World War II and during the invasion of China, both countries were successful, mainly because of the quality and quantity of their equipment advantage. True, they had a certain manpower advantage too, but when the weight of Allied equipment exceeded that of Germany and Japan, the fortunes of war turned against the latter. From the beginning of time, examples may be found to illustrate that superior equipment wins over mere manpower superiority—David's slingshot, the English long bow at Agincourt, and Napoleon's artillery, to name but three.

Not only must we develop and produce superior weapons, but we must maintain the sound economy essential to continued productive capacity if the man at the front is to be effective. These requirements are part of an inseparable whole in maintaining the security of our nation.

With the balance of manpower supply in favor of our potential enemies, it is of the utmost importance that we make the most effective use of what we have. This utilization is not merely a problem of furnishing men in uniform for military service. It also involves a coordinated plan for strengthening productive agencies—designing and developing equipment to continually improve our standards of living and ability to produce; designing and developing better equipment for defense.

Any successful program of defense must take into account that the survival of the United States as a free nation will depend *on superior scientific and engineering skills* to offset the superiority in numbers of men which free nations lack. In addition to an over-all deficit in numbers for our military forces, we are faced with a critical shortage of persons having specialized skills and experience, especially in the fields of engineering and science. A basic consideration is the necessity for training and developing the specialists we need in the future—engineers, scientists, diplomats, doctors, farmers, professional military personnel. We must not repeat the mistakes we made in World Wars I and II when training for civil pursuits was, to a major extent, suspended to meet the emergency of the period. We must realize that we now face a situation of indefinite continuance, not a brief or transient one.

Should there be all-out war, the requirements of the Armed Forces will be great. It may be assumed that every physically fit young man is destined to serve in uniform, *unless it can be shown by clear and convincing evidence that he can serve the nation to better advantage in industry, agriculture, or some other pursuit which vitally affects the national health, safety, and interest.*

The policy which we advocate would involve withholding from the total pool of men of military age, presently numbering 10,000,000 physically fit between the ages of 18 and 30, only those of the highest technical and professional qualifications, and reasonable numbers of trainees to attain such qualifications. The screening procedure will involve selection of the very highest order and must be conducted with great care if public confidence is to be maintained. This policy would require the deferment of about 500,000 young men, or 5 per cent of the age group in question. This 500,000 constitutes a segment critical to present and future technical superiority. Otherwise, the requirements for technical manpower must be met out of the pool of older men, women, 4F's, and underage persons, and the flow

of younger men into technical fields will be interrupted. The young engineer is in many cases equally in demand, sometimes even more than his more experienced confrere, for much of the technology now critically important is so new that only recent students have any training whatever in its application. A belief that the technical requirements of industry can be met by men generally over military age—even if there were enough of them—is therefore a fallacy.

National Manpower Mobilization Policy

A National Manpower Mobilization Policy was promulgated by the President on Jan. 17, 1951. This statement enunciated the principle: *"each individual will be expected to serve in the capacity in which he can contribute most to the total mobilization program."* It provided for fulfilling manpower requirements not only for military purposes but also for the maintenance of a strong domestic economy, and the provision of materials for essential needs, both military and civilian. It is a basically sound policy.

However, it is evident that this policy has not been fully followed by the various executive branches of the Federal Government as the underlying basis for their procedures. In the call-up of reserves, and in the disposition of individuals after call-up, the military departments seem to give first consideration to numbers and to availability rather than to qualifications. Inadequate weight is given to the role of the individual in the essential civilian economy in determining whether or not a man should be called for military service. ROTC graduates are subject to call in substantial disregard of their individual qualifications or of their contributions in nonmilitary capacities. In the Services, the individual's military duties are primary and the utilization of his specialized skills is secondary. This permits highly inefficient use of uniformed personnel having special skills, even in those technical branches of the Service which are, at the same time, determinedly recruiting civilian engineers and scientists.

The Engineering Manpower Commission of Engineers Joint Council strongly recommends that every effort be made by all agencies of industry and government to follow implicitly the principles delineated in the National Manpower Mobilization Policy. It recommends further that in the development of a program for manpower utilization in relation to national security, more consideration be given to the value of building the potential for production of essential equipment for the Armed Forces. This is of far more importance in providing for the successful defense of the nation than is the mere build-up of numbers of military personnel. In general, it is much simpler to procure and train men for military service than it is to train men for the expansion of industrial capacity.

Definitions

In order to clarify the following discussion, it is well to outline the meaning or significance placed upon terms used to designate the various patterns proposed for manpower utilization.

(1) *UMT, Universal Military Training*—a term applied to any of several plans for *training* our physically fit manpower. The plan submitted to Congress by the National Security Training Commission called for the induction of young men at age 18 for six months' training. At the end of their period of training they would be placed in a reserve component for an obligated service in the reserves of 7½ years. The predominant feature of UMT plans is a peroid of *military training followed by an obligated period in a reserve component.*

(2) *UMS, Universal Military Service*—a term applied to any of several plans provided for an obligated period of *active military service.* The basic plan for UMS proposed that *all* physically fit men be placed in active service for two years commencing at age 18. Variations of this plan have been suggested to permit the period of service to be postponed for educational purposes, but only until graduation or cessation of training. The pre-

dominant feature of UMS plans is a period of *compulsory service in uniform for all physically fit men without regard to the occupation, capabilities, or training of the individual, or the probability that he might best serve the nation elsewhere.*

(3) *Selective Service*—a term applied to the plan established by law for *selecting* from those who have military service liability: (1) those who are to enter military service in accordance with the needs of the Armed Forces, and (2) those with special skills who are to continue to serve in the essential economy including defense industry. The predominant feature of Selective Service is the *selection of manpower for service in accordance with both need and skill.*

Universal Military Training

Most informed persons agree that for many years to come, the United States and its allies must maintain a substantial degree of preparedness. Some venture the opinion that preparedness must continue at approximately the present level for a period of twenty years; other believe as long as fifty years. If we continue to maintain 3,700,000 men in uniform, on the basis of present population distribution, about three years' service will be required of each physically fit young man either before or after his college or other training.

In an emergency of such long duration it seems advisable to establish by law the obligation of all persons to train for the defense of the nation and to defend it in time of emergency. The training phase should be universal and should exclude only those who are physically unable to take any training, military or otherwise. It should be so timed as to interfere to a minimum degree with the education or employment of the young men concerned.

After training, the trainee will normally pass into a reserve from which he will be subject to call in event of emergency. Governing such recall, there must be a system of selection which will either call the man for military service or defer him in the national interest if his retention in civilian life is essential to the national health, safety, and interest.

In considering the necessity for training, we must not lose sight of the fact that until recently, we have been relying largely upon those who comprised the Armed Forces in World War II. This is demonstrated by our Korean experience when it has been necessary to recall combat veterans of World War II for the build-up of the Armed Forces. The veteran segment of the reserve is diminishing every day, because the men and women are getting older, are acquiring physical disabilities or a dependency status; or other situations tend to make them less available for military service. While men cannot be trained in substantial numbers while the entire pool is drained for immediate service, as at present, we should move at the earliest possible moment in the direction of training our young men and creating a continuing reserve, if the nation is to be secure.

The Engineering Manpower Commission of Engineers Joint Council recommends that a practical plan for Universal Military Training be developed and enacted into law. Provision should be included to implement the reduction of our standing Armed Forces so that the training of our young men and the creation of a continuing reserve through UMT can commence as early as practicable.

Universal Military Service

Many plans have been proposed involving some form of Universal Military Service, i.e., service in uniform for *all* in a stipulated age bracket, except for those not physically fit. Modifications have been proposed to permit the period of service to be postponed for students satisfactorily pursuing courses of higher education. Other modifications suggest deferment of apprentices, or the assignment of men for compulsory service as civilians in military research and development. Generally the proposals stress a universal obligation to serve *in uniform* as being "democratic," and as such, essential to the American way of life. Actually, service

at the highest capability, whether in uniform or out of uniform, would seem to be the most desirable goal.

Should Universal Military Service be adopted, there would be a suspension in the output of engineering and scientific graduates, other than the physically unfit, needed to serve in industry, of new agricultural manpower needed for our economy, and of new teachers and educators also sorely needed. This suspension would last for two or more years under presently proposed plans. In view of the current shortages in specialized fields, we cannot afford suspension for such a period. It furthermore seems likely that the interrupted training represented by military service of such length will make the integration of these young men into industry more difficult and thus, in effect, add to the period of loss of their services.

The Engineering Manpower Commission of Engineers Joint Council, as has been stated, is in favor of a *selective* system which will co-ordinate the manpower needs of the military with the manpower requirements of essential industry, including the production of more and better equipment for defense. For this reason we are opposed to Universal Military Service as being prejudicial to national security.

Selective Service

The Selective Service System as presently constituted has been operating not only to select people for induction into military service but also to select those for retention in the essential civilian economy.

In the fields of medicine and agriculture, the various local boards and state directors of the Selective Service System have state and county boards and committees to advise them with regard to personnel selection in these fields. In the case of medicine, requests for doctors, dentists, veterinarians, and allied skills are actually submitted to the County Medical Boards for filling rather than to the Selective Service System. The County Medical Boards are in a position to designate those doctors who can best be spared to fulfill the requirements of the military services.

In the case of agriculture, state and county Agricultural Mobilization Committees have been organized under the administration of the Department of Agriculture. These committees provide facts to assist the local boards and the state directors in the Selective Service System with respect to classification of registrants in this field.

No provision exists to cover such advisory service at local and state levels, either to the Department of Defense or to the Selective Service System, in other specialized fields such as engineering, the sciences, and education. As a consequence, many local boards do not have sufficient facts to make a wise and just selection in the over-all interests of national security. The Engineering Manpower Commission of Engineers Joint Council recommends that the Selective Service System be strengthened to provide advisory services to the local and state boards for such specialized personnel through state and county advisory committees, composed of representatives of industry and the specialized professions. These committees will provide advice with respect to such personnel comparable to that now furnished in the fields of medicine and agriculture.

Armed Forces Reserve

On July 9, 1952, the Armed Forces Reserve Act of 1952 (P.L. 476) became law. In addition to providing some uniformity in the over-all administration of the reserve components, this act establishes a Ready Reserve, a Standby Reserve, and a Retired Reserve. The Ready Reserve is that portion liable to immediate recall. It is limited by the Act to 1,500,000 men, including the National Guard. The Standby Reserve includes all other reservists liable to recall but not necessarily immediately. The Retired Reserve, as its name implies, contains those reservists who are retired but may be recalled for limited duty in the event of war.

The Ready Reserve will actually contain that segment of trained reservists and units needed for an immediate mobilization effort in the event of national emergency declared by the President, or police action such as that in which we are now engaged in Korea. Outside of the National Guard and Air National Guard, it is most probable that the Ready Reservists will be called as individuals to bring the cadre of existing service units to full mobilization strength.

The Standby Reserve will contain all other reservists except those on the retired list. Within the Standby Reserve, however, there will be the active organized units which will be required in the event of total mobilization or war as declared by the Congress. The Standby Reserve thus will be similar to the Reserve as maintained before the passage of P.L. 476.

Notwithstanding testimony before the Senate Armed Services Committee by the Engineering Manpower Commission of Engineers Joint Council and others urging provisions for the *selective* recall of reservists (which testimony, we thought, was well received) the Armed Forces Reserve Act of 1952 was passed without such a safeguard. Therefore we feel that it does not provide for the best utilization of manpower in the national health, safety, and interest.

Section 4(*d*) of the Universal Military Training and Service Act (P.L. 51) provides for a total period of liability of eight years of active training and service in the Armed Forces and in a reserve component for all persons below age 26 who are inducted, enlisted, or appointed after June 19, 1951. It established, for the first time in our history, a compulsory reserve. It is evident that eventually practically all of the able-bodied young men below age 26, or older, except for those making a professional career in military service, will be in a reserve component of the Armed Forces to complete their term of liability, and thus subject to recall.

By the time they are recalled to active military service, many members of both the Ready and Standby Reserves will have acquired specialized skills and experience that would make their recall detrimental to the total defense effort. These are the persons who should be identified by a careful classification and selection process in order that the needs of defense industry and the essential civilian economy will not be seriously hampered by their recall to active duty.

Some provision must be included in the law, therefore, to conserve reservists having specialized skills and experience when their service in a civilian capacity would contribute more to the national strength and security than their service in uniform. Reservists who do not have an obligated period of service should be discharged. Reservists who have an obligated period of service should be transferred to an inactive status list from which they would not be called or from which their recall could be governed by a civilian agency or board outside the military departments. This civilian governing board should have the authority to render final decisions. It should be composed of representatives of the Department of Defense, various other governmental departments, the professional groups involved, and the military departments.

The civilian governing board would be the top board at the national level. In order to maintain public confidence and to reduce the volume of individual cases which would otherwise have to be reviewed at the national level, local and/or state boards should also be organized. The local and state boards should be composed of representatives of the professional groups involved and of the military departments. They should, however, remain civilian in character and have authority to render decisions within the framework of criteria established by the national board.

In order to reduce to a minimum the problems which would be encountered in a full-scale mobilization, there must be a continuing appraisal of the classifications of reservists to insure to the maximum possible extent that those who have

specialized skills and experience are properly classified before mobilization takes place.

Some provision must also be included to insure the continuance of the education and training of specialists needed in the future. Students who are pursuing professional and scientific courses in the colleges should be permitted to complete their study before being considered for recall to active duty. Many of them will be needed by the technical branches of the Armed Forces as well as in other essential activities of the national economy.

The Engineering Manpower Commission of Engineers Joint Council, therefore, recommends that the Armed Forces Reserve Act (P.L. 476) be amended accordingly.

ROTC

Because of impending military service there has been a greatly increased enrollment in ROTC units by students entering the colleges. In a large measure this may be attributed to the assurance of completing their college education without disturbance and of receipt of commissions on graduation.

In the past when students enrolled in the Air or Army ROTC, they had the privilege of applying for two years of advanced training *after completing two years of basic training.* Students who were enrolled in the Naval ROTC, however, were obliged to complete four years of training. Enrollment in advanced Air or Army ROTC courses therefore, until this year, has been optional on the part of the student.

With the current operation of Selective Service there has been increasing pressure exerted by the ROTC officers to have all students in the ROTC sign draft deferment agreements. These draft deferment agreements commit the student to the completion of four years in ROTC and acceptance of a commission, two years' active service upon graduation, and six years' additional service in a reserve component.

A recent survey made in the engineering colleges revealed that 16 per cent of the seniors of the class of 1952 were commissioned as a result of ROTC training as compared with 11 per cent of the previous year's graduates. Examination of the enrollments in ROTC in the *undergraduate* classes, however, shows that 23 per cent of the juniors are so enrolled, 45 per cent of the sophomores, and 55 per cent of the freshmen.

The survey from which these figures were obtained was made by the Engineering Manpower Commission in May, 1952. It covered returns from 174 out of a total of 192 engineering colleges in the United States. It is evident from this that an increasing number of engineering graduates each year will be committed to a period of service sufficiently long to hamper the needs of essential industry unless provision is made for their selective withdrawal from service liability.

To add to the problem, it has been decided, beginning this year, to convert Army and Air ROTC units to Branch General training and to discontinue curricula in the technical specialties. Upon graduation, assignments will be made to the various branches, technical and combat, in accordance with the requirements of those branches, and the training and standing of the students. The advocates of this change state as a primary advantage that it trains cadets essentially for combat and makes it possible for the Army and Air Force to obtain a larger percentage of combat officers.

The Engineering Manpower Commission heartily supports the general ROTC concept that American colleges and universities should be utilized for the purpose of training reserve officers, especially those needed in the technical branches of the service. We feel, however, that proper utilization of graduates having special training such as in engineering and science, may indicate that officers for the technical branches of the service should be obtained through the ROTC, and combat officers through Officers Candidate Schools. We therefore recommend that further study be given to the ROTC

program, especially with respect to the effects on manpower utilization of the trend toward Branch General training.

We recommend also that new criteria be established in choosing students for ROTC programs in order to assure a more equitable distribution between civilian and military needs. The present method channels into ROTC units a disproportionate share of students capable of and needed for graduate training and for other essential activities. Realistic quotas should be established in the various military categories, and every effort should be made to restrict the entrants to accord with such quotas and to match their fields of specialization.

Reservists who are ROTC graduates should be subject to the same screening, classification, and selective recall as has previously been recommended for reservists in general in the proposed amendments to the Armed Forces Reserve Act.

We also recommend that Selective Service regulations be modified to permit students in engineering, science, and other critical fields to receive the same assurance of completing their education as is now provided to those enrolled in the ROTC units.

Utilization of Persons Having Specialized and Critical Skills

Concurrently with the universal obligation of each man and woman to furnish his best service in maintaining the national security is an obligation on all agencies—military and nonmilitary alike—to utilize manpower in such manner that the most proficient service can be furnished. This is especially true with respect to those persons possessing critical and specialized skills in short supply.

The present shortage of engineers and scientists is serious because of its effect on the national economy and on national security. If we do not utilize our limited manpower effectively, we will lose technological superiority over our probable enemies. With such loss, the probability of a full-scale war with the forces of communism will become infinitely greater.

The Engineering Manpower Commission of Engineers Joint Council urges in the national interest that the following steps be taken:

(1) *Military Utilization*

(*a*) Establish manpower budgets for engineers and scientists in each activity, in accordance with actual needs for their professional skills and experience. A catalog of requirements is vital as the first step toward maximum utilization of the total supply.

(*b*) Eliminate confusion in the distinction between a *professional engineer* and *a technician* by discontinuing references in billet designations, military occupational specialties, and elsewhere, to the word *engineer* except where the position requires an engineering graduate or scientist. Re-examine those enlisted billets which now apparently require an engineering graduate or scientist to determine whether the billet cannot be filled by a competent technician. Technicians can be trained in a matter of months; the professional engineer or scientist is the product of at least four years of full time study coupled with more years of development and experience.

(*c*) Recall engineers and scientists to active duty only to the extent they can be *fully* used in their specialties.

(*d*) Provide for commissioning in their specialties all engineering graduates and scientists who are inducted through Selective Service, or who are enlisted reservists, to permit full utilization of their skills.

(*e*) Provide for interservice transfers of persons having special skills in order to provide a wide base of utilization of their skills. For example, this would permit the transfer of aeronautical engineers or meteorologists, when needed, from the Army to the Air Force or to the Navy.

(*f*) Provide for the release from active duty of those engineers and scientists not needed as such.

(2) *Civilian Utilization* (including utilization in government, agriculture, trans-

portation, manufacture, and all other activities outside of the military).

(*a*) Establish manpower budgets similar to those recommended for the military.

(*b*) Study the duties, and the proportionate time spent on each duty, of engineers and scientists, in order to transfer to supporting personnel those duties not requiring full engineering or scientific skills. Many such duties can be performed equally well, if not better, by technicians, clerks, draftsmen, and others. Do not hire engineers or scientists for positions in which their skills are not required.

(*c*) Move engineers and scientists from positions not requiring professional engineering or scientific training.

(*d*) Move engineers and scientists to positions of maximum responsibility as rapidly as possible in accordance with need, ability, and experience.

(*e*) Do not hold engineers or scientists in "intern" or training positions longer than necessary to qualify them.

(*f*) Maintain salary differentials between senior engineers and scientists and those newly graduated. Competition for new graduates has resulted in unprecedented levels of starting salaries.

Summary of Recommendations

In the interest of national security the Engineering Manpower Commission of Engineers Joint Council recommends that:

(1) All segments of our economy, governmental and non-governmental alike, follow implictly the principles delineated in the National Manpower Mobilization Policy promulgated by the President on Jan. 17, 1951, in their procedures and programs for manpower mobilization and utilization.

(2) In the development of programs and plans for national security more consideration be given to the value of building the productive potential and a coordination be effected between this and our manpower needs. Greater productive facilities are of far more importance in providing for the successful defense of the nation than is the build-up of military forces during times of peace or partial mobilization.

(3) A practical plan for Universal Military Training be developed and enacted into law. Provisions should be included to reduce our standing Armed Forces as early as practicable so that the training of our young men and the creation of a continuing reserve through UMT can be commenced.

(4) Plans for Universal Military Service as presently proposed be abandoned as unsound and prejudicial to the national security.

(5) The Selective Service System be strengthened to provide advisory service to local and state boards with respect to professional and specialized persons. Such advisory services should be provided by county and state boards, composed of representatives of industry and the professions, to furnish competent advice with respect to the essentiality in the national security of certain civilian services, and the specific value of the individual who is subject to induction based upon his specialized and critical skills.

(6) Selective Service regulations be modified so that college students in engineering, science, and other critical fields may be given the assurance of being able to complete their education before being inducted, in the same manner as is now done for those enrolled in ROTC programs.

(7) The Armed Forces Reserve Act of 1952 be amended to provide for the creation of a Civilian Reserve Governing Board, outside of the military departments, to establish criteria for, and render final decisions with respect to, the classification and mobilization assignment of reservists having specialized skills and experience, and to maintain a continuing process of classification of such reservists.

(8) The Armed Forces Reserve Act of 1952 be amended to provide for the creation of local and state Civilian Reserve Boards operating under the Civilian Reserve Governing Board to render decisions at the local level with respect to the

classification, mobilization assignment, and delay in recall to active duty of reservists, within the framework of the criteria established by the Civilian Reserve Governing Board.

(9) The Armed Forces Reserve Act of 1952 be amended to provide for the continued training of professional and scientific personnel without interruption.

(10) The present trend in ROTC units toward providing only Branch General training and discontinuing technical curricula be re-examined in the light of its effect on utilization of those with special and critical skills.

(11) New criteria be established for choosing students for ROTC programs to insure distribution of graduates between military and civilian agencies on a basis which will better satisfy national needs.

(12) Realistic quotas be established for the various ROTC programs and entrants be restricted within these quotas and in accordance with needs for their fields of specialized training.

(13) All segments of our economy, governmental and non-governmental alike, take specific steps toward full utilization of persons possessing critical and specialized skills in short supply in the best interest of the country as a whole rather than in their special interest. To this end, it is important that budgets of specialized manpower needs be established, and that the duties performed by specialized persons be thoroughly studied in order to reallocate them to less highly skilled persons to the maximum possible extent.

Conclusion

During the period of approximately two years of its existence the Engineering Manpower Commission of Engineers Joint Council, either on its own or in cooperation with other agencies, has undertaken the following activities:

(1) Offering assistance to governmental bodies and groups responsible for making and administering policy relating to the conservation and utilization of engineers and scientists.

(2) Providing help and guidance to both industry and government on other problems relating to the conservation and utilization of engineering and scientific skills.

(3) Disseminating information on the nature of engineering and the role it plays in our economy.

(4) Striving to prevent future shortages in engineering graduates by cooperating with the Engineers' Council for Professional Development and others in encouraging qualified highschool graduates to consider the opportunities in engineering and science.

(5) Advising governmental agencies and the colleges on problems relating to the deferment of engineering students from military service.

(6) Advising employers of the conditions under which deferment of engineers and scientists may be secured and of the procedure to be followed in such cases.

In furtherance of this program, we wish now to pledge our support of all efforts to assure in industry, government, and other segments of our economy, the same zeal and intelligence in selection, training, and utilization of technical manpower that we are here urging upon the military establishments; for in such measures, in our opinion, lies the opportunity for maximum contribution of the technical professions to national security.

The Engineer Becomes a Professional Manager*

By HARRY RUBEY

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Introduction

This Centennial is a well deserved tribute to the achievements of the engineer and to his application of science to the material welfare of mankind. The general public is beginning to realize that the engineer's universally accepted technology is the real basis for modern industry, high living standards, and national security—not the controversial political and economic nostrums which are dinned into our ears.

However, too little has been said or is generally known of the equally great contribution which the engineer has made to modern management. Beginning with Taylor, Gantt, Emerson, and their associates who originated and developed scientific management and mass production at the turn of the Century, engineers have extended their attainments and mastery to all phases of management, often at the highest levels.

Today over a third of the management of large industry in America is in the hands of engineers, over a third of mature engineering graduates now find their duties largely managerial in nature, and most engineers have important contacts with management. Management has recently become a profession into which the engineer now has preferred entree.

May I briefly summarize and document some of the evidence on this development which is unknown to the general public and too little known to engineers and engineering educators themselves. Even so comprehensive a program as that of this Centennial gives little attention to the engineer's outstanding contribution to management.

Recent Studies of Engineers in Management

Professor W. L. Warner, well recognized sociologist of the University of Chicago says in his recent book, "Social Class in America," "More and more top jobs in industry are being filled by men coming up from technical engineering schools and universities. The route up then is no longer through a hierarchy of increasing skill as it was two generations ago. The prudent mobile man today must prepare himself by education. . . . In this age of technical wizardry and large scale industry, the most prudent man will master a field like engineering or business administration to gain a maximum chance at promotion to the inner circles of management and planning."

Engineers' Joint Council Report. The most comprehensive statistics available on the engineering profession are given in a report entitled "The Engineering Profession in Transition," 1947. It shows 34 per cent of those questioned (38,000 members of six principal national engineering societies) doing work which is primarily administrative in nature. In another report the Council states ". . . management is clearly becoming professional in function. Engineers, as the most numerous and influential professional group in industry, are exceptionally placed to capitalize on this opportunity."

Vice-President Walter Evans of Westinghouse Electric Company has said:

"With mass production the engineer came into his own. As industry became

* Prepared for the Centennial of Engineering, Chicago, September 4, 1952.

more complex, the engineer who understood what was happening joined the lawyers and bankers in administrative positions, because industry had new problems which only the engineer could solve.

". . . during the last decade engineers have begun crowding the bankers and lawyers in this contest for high-level administrative posts. . . .

"A dramatic example of how successful the engineer has been is found in a survey conducted by Earle B. Norris, dean of the School of Engineering at the Virginia Polytechnic Institute, which showed that one-third of the largest corporations in America—50 out of 150—are headed by graduate engineers. . . .

"In looking at the results of this survey it becomes even more significant when we realize that there are 1,600 liberal arts and teachers' colleges compared to 160 engineering colleges.

"Among the engineers already distinguishing themselves in such posts are: Cleo F. Craig, president of the American Telephone and Telegraph Company; Benjamin F. Fairless, president and chairman of the board of United States Steel Corporation; Eugene G. Grace, chairman of the board of Bethlehem Steel; Charles Erwin Wilson, president of General Motors; and Crawford H. Greenewalt, president of E. I. du Pont."

Rensselaer Polytechnic Institute questioned 561 executives of large industries in 1949 with the following findings:

1. Ninety per cent see a growing demand in business and industry for executives and managers who have a background in engineering.

2. Approximately thirty-nine per cent of the executive and managerial positions in the industries represented by respondents to the survey are now held by graduates of colleges of engineering.

Time Magazine Research Report No. 1069, May 1950, summarized the answers to the questionnaire sent one-sixth of those listed in "Who's Who in Engineering." Seven per cent are corporate presidents, and an additional sixteen per cent are in other top executive positions. Thirty-five per cent are managers, chief engineers, and department heads while forty-two per cent are specialists and consultants.

Sixty-three per cent of these engineers checked administration, finance, and management as areas in which they have occupational responsibilities.

Because many management engineers are not listed in Who's Who in Engineering nor are they members of their national professional societies, the percentages of engineers engaged in management as reported by Time and by Engineers' Joint Council are doubtless low.

The American Society for Engineering Education, in a 1951 pamphlet, states, "A careful study of the number of engineering graduates who hold executive positions in industry has shown that engineers have from 10 to 20 times the probability of attaining executive positions as compared with all other college graduates."

General Motors, in a broadcast over ABC on November 26, 1951, stated in part:

"Tonight, I just want to conclude this assembly of three broadcasts in this investigation by pointing out the amazingly widespread climb of engineering-qualified students to the top, as general executives, in American enterprises—in short, the enormous individual possibilities in this opportunity, based on the record.

"According to a Columbia University survey, and I quote, I find that 'forty per cent of industrial management is engineer-trained, replacing both the lawyer and the banker in top industrial posts.'

"Look at some of the top management in our country, men with great general responsibilities. I think you would be amazed to realize how many got their training as engineers—thus trained to think precisely, trained in human values, trained to apply constructive imagination and decision.

"Largely at random, and among diversified and notable American enterprises, I've been asking questions: 'How

many of your top executives trained themselves as engineers?' This is what I found:

"I spoke last week of Bethlehem Steel, and the head of that company, who is an engineer, graduated from Lehigh.

"The president of United States Steel, having some 308,000 employees all over the world, started as an engineer, a civil engineer, graduated from Ohio Northern University. There are 13 Presidents of the United States Steel Company's subsidiary companies who started as engineers.

"There are 20 Presidents of associated companies in the great Bell Telephone System. Of these I find 10 graduated as engineers. In the parent A T & T, over half the men who are Vice-Presidents started as engineers and advanced to the broadest duties in the business.

"Fourteen members on the Board of Directors of the Standard Oil Company of New Jersey are engineers. The Chairman of the Board in this great worldwide enterprise is an engineer, graduated from Syracuse University.

"At least 15 top executives of Anaconda Copper and its major subsidiaries are graduate engineers. Over half the Vice-Presidents and 90% of the top executives in the five divisions of Union Carbide started up the ladder as engineers.

"Nearly half the top officials of the General Electric Company started as engineers. In fact, the Chairman of the Board was first graduated as an engineer at the University of Wisconsin and studied law as well. And, as you may know, Mr. C. E. Wilson, lately the nation's mobilization chief, while not a graduate engineer, was technically trained at the Mechanics' Institute in New York and, among other duties, he advanced through G. E.'s Engineering Department.

"The Chairman of the Board of RCA completed special engineering night courses at Pratt Institute and 8 of the Vice-Presidents got their executive training as engineers.

"The Chairman of the Board of Directors of General Motors is an engineer, graduated from M. I. T. The President of General Motors is an engineer, graduated from Carnegie Institute. One of the four Executive Vice-Presidents is an engineer, graduated from the University of Illinois. Sixteen of the Corporation's Vice-Presidents are engineers. As a matter of fact, there are sixteen members of the Board of Directors of General Motors who are engineers.

"Now, there's time to cite only some of these findings, but such sample cases as I found simply support the over-all findings of the Columbia University survey, namely—and may I repeat—that 'forty per cent of industrial management today is engineer-trained, replacing both the lawyer and the banker in top industrial posts.' I think there's news in that."

President Gurley of the Sante Fe Lines said at the A.R.E.A. meeting last March, "No longer can engineers confine their activities to design, construction, and maintenance. Theirs must be a broader outlook. Both management and the engineers themselves have mistaken concepts of where the engineer fits into the picture. Engineers should concern themselves more with administration. Their logical technological reasoning can help improve the economical operation of the railroads, reduce the damage to property being shipped, and develop more revenue-paying business now going to competitive forms of transportation." It will be noted that President Gurley indicates new activities beyond those traditional to railroad engineering.

Herbert Hoover even more recently has written, in connection with this Centennial, "In the gigantic field of applied science, the trained engineer is now emerging into the executive field. It is said that the heads of more than one-half of the great productive corporations are trained engineers."

Conclusion

So while at this Centennial we honor the engineer for his technology, we should

honor him equally for his contribution to management.

The data presented earlier in this paper prove that an engineering education is a good preparation for positions in top management, but it does not follow that the same large proportion of engineering students of today will be among the top executives of the next generation. When the older top executives were starting their careers, they had little competition from the graduates of schools of business administration. That is not the case today. In fact, many of the larger manufacturing companies will freely admit that they find business administration graduates more interested in, and more easily trained for, general management positions than are engineering graduates.

The conditions I have just described are so bad that according to the National Society of Professional Engineers, two-thirds of industrial concerns make no effort to tell their engineers of management openings. Fortunately, young engineering graduates who realize the importance to themselves of a knowledge of management principles, and who show their employers that they are interested, have at least as good an opportunity to enter the management side of industry as did the engineers of the earlier generation.

Only a few engineering students can afford the time required for the detailed and specialized courses in industrial engineering curricula, but all engineering students can afford the small amount of time needed to introduce them to the fundamentals of management. This also will show them that they should continue to study these fundamentals during their early years after graduation when management problems will surround them, although in most cases they will not be asked to assist in their solution.

While many engineers will not function as managers, yet the higher types of professional engineers must understand and cooperate with management.

A promising movement for our country lies in that new profession of management, largely practiced by engineers, which is motivated by a drive to make man's work effective rather than by the older drives for financial or political power. With professional management and technology, America's future is assured. Other national policies and procedures then will trend naturally into desirable patterns.

Unless engineers and engineering educators seize and answer this call to leadership, others will grasp and exploit it. Then the engineering profession, engineering education, and industry will have missed a great opportunity. As a final thought, if more engineering graduates become managers, then more support for engineering education will be forthcoming.

5th College-Industry Conference

THEME . . . Opportunities in Engineering

Sponsored by the Relations with Industry Division of ASEE and Northwestern University at Northwestern Technological Institute, Saturday, January 31, 1953.

Minutes of Executive Board Meeting

A meeting of the Executive Board of the American Society for Engineering Education was held on Thursday, November 13, 1952, at the Statler Hotel, Washington, D. C. Those present were: W. R. Woolrich, *President*; M. M. Boring, J. H. Lampe, E. A. Walker, W. C. White, *Vice Presidents*; C. L. Skelley, *Treasurer*; A. B. Bronwell, *Secretary;* M. C. Merrill, *Office Secretary.*

The Secretary reported on activities as follows:

a. An appropriation of $3000 has been received from The Engineering Foundation for the project of the Committee on Evaluation of Engineering Education. An application has been made for a like appropriation from the Engineers Joint Council.
b. Letters have been sent to the Presidents and Deans of Engineering Colleges summarizing the results of meetings which Society Officials have held with the Army, the Air Force, and the American Council on Education relating to the ROTC Programs.
c. Letters have been sent to the Deans of Engineering Colleges suggesting that they urge college graduates to carry on personnel interviews and make tentative job commitments before they enter the Armed Services so that they will return to acceptable engineering jobs. The purpose of this program is to achieve a better utilization of technical manpower among those who are destined for duty in the Armed Forces.
d. The December and January issues of the JOURNAL OF ENGINEERING EDUCATION will be devoted to papers presented at the Centennial of Engineering.
e. The Society's application for representation on the United States Commission on UNESCO was not approved, although favorable consideration was given. The Chairman of the Membership Committee of the U. S. Commission has suggested that the Society re-apply for admission.

Treasurer's Report

The Treasurer discussed the financial report for the first quarter of 1952. Most items of income and expense are in line with those of the preceding year except salaries, which were increased by action of the Executive Board. The quarterly report for 1952 includes the salary of the Assistant Secretary who was not on the payroll during the corresponding period of 1951.

The campaign for increased advertising, conducted by Assistant Secretary Watson, has thus far yielded $2700 in new revenue for the current year. It is anticipated that this will be still further increased before the fiscal year is concluded.

Projected Society Finances

The Secretary submitted to the Executive Board a summary of financial operations for the past five years and tentative forecast of the financial outlook in the future. The estimated income provides for increases in revenue from advertising, membership, and institutional membership. The estimated expense provides for the addition of 1½ office secretaries and probable increases in expenses including rising costs of publication. The report shows that the Society has one staff member to every 2000 members, whereas other leading engineering societies have approximately one staff member to every 200 to 400 society members. The Society dues are one-fourth to one-fifth of those of other engineering societies. The small

overhead expense and low dues structure has been made possible by: (a) free rent and facilities (Northwestern University supplies the office space and office furniture without cost to the Society); (b) prudence in travel expense; (c) avoiding subsidies to Sections; (d) and a minimization of the collateral services rendered to the membership.

Representatives of A.S.E.E. to Conference on Education in London

The Secretary read a letter from C. E. Davies, Secretary of ECPD, requesting the ASEE to appoint its President as a delegate to an International Conference on Engineering Education which will be held in London during the week of January 12th. This conference will be attended by representatives from all European countries outside the Iron Curtain. Its purpose will be to establish a European conference on engineering education and explore possibilities of instituting a European Society for Engineering Education. The Executive Board expressed the view that it is essential that the ASEE be represented, since it deals primarily with Engineering Education. The President was appointed as the official representative, with an appropriation of $1000 for travel expense.

Reports of Vice Presidents

Vice President Boring suggested, and the Executive Board approved, sending invitations to Queens University, McGill University, and Montreal University to affiliate with the New York Section of the ASEE until such time as they should desire to institute their own Section. It was also suggested that Nova Scotia College might be invited to join the New England Section, and British Columbia, the Rocky Mountain or Pacific Northwest Section. Mr. Boring will correspond with the Canadian Institutions in regard to their desires in these matters.

The suggestion has been made that the name of the Missouri Section be changed to the Missouri-Arkansas Section. Mr. Boring will correspond with officers of the Section relating to this change.

Vice President Walker, reporting for the ECRC, announced that a questionnaire for information for the new publication Review of Research will be sent to the Engineering Colleges in the near future. ECRC has made tentative plans for its program for the Annual Meeting in June.

Vice President J. H. Lampe, reporting for the ECAC, briefly summarized the ROTC meetings which were held in Washington, results of which have been summarized in letters to the Presidents and Deans of Engineering Colleges. The Executive Committee of the ECAC has prepared plans for the June Program. The International Relations Committee again will hold a dinner meeting at which educators and administrators of engineering colleges from foreign lands will be invited. The Secondary School Committee, the Selection and Guidance Committee, and the Manpower Committee will each have conference programs at the Annual Meeting.

Vice President W. C. White, reporting for Divisions and Committees, stated that the Division of Educational Methods had requested an exhibit of teaching aids at the Annual Meeting, in cooperation with the Society's Committee on Teaching Aids. The Executive Board voted to approve such an exhibit.

Vice President White also presented a request of the Mathematics Division for a subsidy of $100 to be used to obtain speakers for a conference on Computers at the Annual Meeting. It was pointed out that the Society had a practice of not paying travel expenses of speakers to the Annual Meeting. However, the suggestion was made that this conference might be arranged as a Summer School. The Society permits Summer Schools to charge a registration fee of not more than $1.50 per member per day to defray expenses in the operation of the Summer School. This would give the Mathematics Division funds for the Conference on Computers in addition to its annual budget.

Report of Manpower Committee on ROTC Quotas

The following report was presented:

The Manpower Committee of the American Society for Engineering Education is gravely concerned over the plans of the Armed Services for expanded R.O.T.C. programs and the consequent effect upon an adequate supply of trained men with high ability for the civilian functions of industry, public health, agriculture and government, essential for support of the national effort.

Under existing programs of the Services, the number of R.O.T.C. graduates receiving commissions will more than double within the next few years, to a total of over 65,000. In 1955 when the number of degrees granted to men is expected to reach its critical low point, to be followed under existing policies by a gradual rise, R.O.T.C. graduates will constitute 40% of the entire male class and nearly 60% of that in engineering.

Pending legislation, moreover, will extend to a substantial number of R.O.T.C. students in the Army and Air Force, the opportunity for a college education with free tuition and a living allowance, now offered under the regular Navy R.O.T.C. program. Such an opportunity added to assure deferment until graduation and the selective process of the R.O.T.C. itself is certain to attract students of the highest ability, many of whom could make outstanding contributions to research in physical, biological or social science, or in engineering.

These men will be committed to at least two years of military service upon graduation and to several additional years in the Reserve, from which they almost certainly would be called in the event of a major War, when the demand will be greatest for research and production. As reserve officers, their contributions to the civilian national effort would be subject to review only by the Military Services.

The Manpower Committee of the American Society for Engineering Education urges that the implications of such a program be reviewed at the highest levels of the Federal Government.

A motion to approve the report and transmit it to Members of the Engineering Manpower Commission, the proper officials in the Armed Services, and the Deans of Engineering Colleges was approved.

(Subsequent to the meeting, Mr. Donald Bridgman, chairman of the ASEE Manpower Committee, suggested that distribution be withheld pending preparation of a more comprehensive report covering the problems relating to ROTC, selective service, and other phases of the technological manpower problem for submission to the new Secretary of Defense, Charles Wilson.)

Meeting of ECAC with Officials of MSA and TCA

Dean Lampe announced that a meeting had been arranged between Officers and Executive Committee Members of ECAC and ASEE Executive Board members with some of the top officials in the Mutual Security Agency and Technical Cooperation Administration to discuss international programs relating to technological education. The Government's Technical Assistance Program includes substantial areas dealing with research and technological education and the ECAC is therefore taking steps to establish closer working relationships with the MSA and TCA in order to make it possible for these agencies to get the advice and assistance of Deans of Engineering Colleges. (The meeting was held in Washington on November 13, 1952, and resulted in the recommendation that the ECAC appoint a small advisory committee to work with similar committees of MSA and TCA.)

Annual Meeting Plans

The Secretary reported on discussions with Dean Weil and Dr. Grinter relating to the plans for the Annual Meeting. The Executive Board voted to hold a business general session on Monday afternoon, 3:00–5:00 P.M. The program of this general session would include committee reports, a report on Society activities, and other general business matters.

Associate Institutional Membership Drive

The Secretary stated that Mr. McKeon is preparing material to be sent out to companies which are prospective Associate Institutional Members. It is hoped that a

substantial number of new Associate Institutional Members can be added this year.

President Woolrich read a letter from Col. C. E. Davies, Secretary of EJC, stating that the Societies making up EJC had expressed hesitation about admitting other Societies to the Unity Organization which have company memberships. Dean White emphasized that the classification of membership in the ASEE is defined by the Constitution and that Associate Institutional Membership classification was included in order to provide a vitally necessary liaison between industries and the Engineering Colleges. Without close liaison between industries and our educational institutions, education would become sterile and academic and would lose the vitality which has been gained by close industry affiliation. It was the opinion of the Board that even closer liaison with industry is desirable and would result in strengthening engineering education and the engineering profession.

The Executive Board suggested that the Division of Relations with Industry consider the problem of studying the relationships between Engineering Colleges and industry in order to make recommendations as to more effective lines of cooperation.

President Woolrich appointed a committee consisting of Jesse McKeon, Donald Bridgman, M. M. Boring, L. Fletcher, and C. L. Skelley to explore ways of increasing membership from among industrial people, particularly the leading engineering personnel in industry. This committee would also recommend means of increasing participation of industrial members in Society activities.

Interchange of Foreign Students for Work Experience

A letter from Dr. Dees of the National Science Foundation was read. This relates to a new organization, the International Association for the Exchange of Students for Technical Experience. The Science Foundation has cooperated with this organization in attempts to develop outlets for technical experience of British students in industries in the U. S. Professor A. H. Tichenor, Jr., of Purdue University has been appointed Chairman of a group in the United States to develop this program.

Earlier in the year, Dean Steinberg was appointed as ASEE representative to the Committee which is studying these proposals. The matter had been referred to the Relations with Industry Division of the ASEE, for their comments. Both the Executive Board Members and the Division of Relations with Industry officers expressed concern over the operational difficulties of such a program. It was pointed out that because of security restrictions, most companies have regulations against hiring aliens and that this made it difficult to place foreign students in American industries. The question was also asked why the United States should bring over a whole new group of students for work experience in this country when there are already large numbers of British and foreign students in this country attending our educational institutions, many of whom will undoubtedly seek job experience before returning to their own country? The suggestion was made that British students could probably get comparable work experience in plants either in England or in Europe, where travel distances and expenses are considerably lower. The Board expressed willingness to cooperate with the project but felt that the ASEE could not take on the responsibility for it or for handling the placement of foreign students in American industries.

Future Annual Meetings

The Secretary read letters from Dean Tupper of the University of Toronto and Dean Eckel of the University of Colorado inviting the ASEE to hold future Annual Meetings at their respective institutions. This was deferred for future action.

Research Study of Educational Methods Division

The Educational Methods Division has proposed to conduct a research study with

the objective of establishing correlations between success of engineering graduates and various factors in the educational program. The Educational Testing Service is planning a somewhat different study to determine primary factors which contribute to success and has solicited funds from industry to conduct this study. The Educational Methods Division of the ASEE is proposing to cooperate with the Educational Testing Service in developing a common project.

The primary concern of the Executive Board relates to the solicitation of funds. The Board suggested that inasmuch as the Educational Testing Service had initiated the solicitation of funds and would probably provide the personnel and facilities to conduct the study, the most expeditious way seemed to be to allow ETS to continue the solicitation, with the Education Methods Division of the ASEE serving in an advisory capacity in helping to develop the testing methods.

Institutional Membership

The Executive Board voted to accept the application of the Standard Oil Development Company for Associate Institutional membership.

The Board also voted to accept the application of Spring Garden Institute for Affiliate Institutional membership.

Respectfully submitted,
ARTHUR BRONWELL,
Secretary

ASEE Sponsored Seminar on Improvement of Teaching

The seminar on Teaching Methods in the Advanced Engineering Program which was jointly sponsored by ASEE and the General Electric Company and held in Schenectady June 16–21, 1952, had at least two unusual features: it was pointed toward teaching method rather than subject matter, and the participating teachers were assigned active roles as problem solvers instead of being passive listeners.

The importance of helping the student learn how to deal competently with engineering situations that are new to him, together with having him learn to do this by practice in doing it, has been recognized by many individuals and by ASEE committees, and has been emphasized recently in the work of the Committee on Improvement of Teaching. Also realistic problem solving as a goal and as a teaching method has been developed and successfully employed in the Advanced Engineering Program of the General Electric Company for more than twenty-five years, and, indeed, has been its distinguishing feature. (Incidentally, the program was established because most engineering graduates were found to be deficient in their ability to deal with new situations on their own initiative and in terms of fundamental principles.) Thus when the question came from the General Electric Company as to what it could do to further the cause of improvement of teaching, the suggestion was made that it might acquaint teachers with the philosophy and methods of the Advanced Engineering Program. It was not expected that these would be directly applicable to engineering classes but rather would suggest and stimulate improvements that individual teachers might work out for themselves. Thus discussions of how the philosophy and method might be adapted to college teaching were a planned part of the program.

Consistent with the principle of learning by doing, accepted by both the Committee on Improvement of Teaching and the Advanced Engineering Program, the attending teachers were given the philosophy of the program by participating in it as students. The problem solving method itself was used to demonstrate the problem solving method. The seminar members began by taking the entrance examination and went on to work and discuss three problems during the week. Brief discussions of the adaptation of the philosophy to teaching occurred every day, and the closing period of the seminar was devoted to overall generalizing and the drawing of conclusions. It was not by any means a week of leisure; the schedule called for outside work on problems during most of the evenings. However, one afternoon was devoted to a plant inspection trip, one evening to a smoker, and the week ended with a banquet.

The seminar was conducted by two regular supervisory staff members of the General Electric Advanced Engineering Program, D. R. Mack and Henry Lehmann, assisted by Professor D. W. VerPlanck of Carnegie Institute of Technology, and these men deserve the credit for the success of the seminar. The entrance examination and two of the problems were typical of the Advanced Course although somewhat scaled down in length because of the shorter time available, and the third was an Advanced Course type of problem which had been developed and used in college teaching. The problems required six to ten hours' work each, were built around

realistic engineering situations, and were of such novelty and level of difficulty as to interest and challenge most of the participating teachers. Problem material was drawn impartially from the general fields of electrical and mechanical engineering.

All the expenses of the seminar, including travel and living costs, were borne by the General Electric Company. Meetings of the seminar were held in Union College classrooms, and members were housed most comfortably in a fraternity house on the campus. Living and working together for a week were conducive to spontaneous informal discussions of education that occurred at any and all hours.

Attendance was limited to twenty-five. Deans or other administrative officials of about fifty institutions throughout the United States were each invited to nominate one candidate, and promptness of response was an important factor in the final selection, since time was short. Some homogeneity of the group was believed, and later found to be, desirable, and so it was suggested that candidates be teachers of either electrical or mechanical engineering, be between twenty-five and thirty years old, and preferably have master's degrees.

While it is difficult to measure the success of an undertaking such as this, the staff and members of the seminar were enthusiastic in their reactions to it. The results of the stimulating week will show up in improvements in future teaching by the participants. We recommend that it be carried on next year on substantially the same basis as this year.

Respectfully submitted,

K. B. McEachron, Jr.

B. R. Teare, Jr.

Section Meetings

Section	*Location of Meeting*	*Dates*	*Chairman of Section*
Allegheny	West Virginia University	April 17–18, 1953	C. H. Cather, West Virginia University
Illinois-Indiana	Rose Polytechnic Institute	May, 16, 1953	H. A. Moench, Rose Polytechnic Institute
Kansas-Nebraska	University of Kansas	Oct. 24–25, 1952	M. A. Durland, Kansas State College
Michigan	Detroit Institute of Technology	May 9, 1953	C. C. Winn, Detroit Institute of Technology
Middle Atlantic	University of Delaware	May 2, 1953	W. B. Plank, Lafayette College
Missouri	Washington University	April 11, 1953	G. F. Branigan, University of Arkansas
National Capital Area	Catholic University of America	Oct. 7, 1952	L. K. Downing, Howard University
	Howard University	May 9, 1953	
	University of Maryland	Feb. 3, 1953	
New England	Worcester Polytechnic Institute	Oct. 18, 1952	E. T. Donovan, University of New Hampshire
North Midwest	Marquette University	Oct. 9–10, 1953	S. J. Chamberlin, Iowa State College
Ohio	University of Cincinnati	May 2, 1953	H. K. Justice, University of Cincinnati
Pacific Northwest	Washington State College	April 24–25, 1953	J. P. Spielman, Washington State College
Pacific Southwest	California State Polytechnic College	Dec. 29–30, 1952	C. E. Cherry, College of Marin
*Rocky Mountain	University of Wyoming		C. A. Hutchinson, University of Colorado
*Southeastern	Louisiana State University	March, 1953	D. V. Terrell, University of Kentucky
Southwestern	University of New Mexico	April 3 & 4, 1953	M. L. Ray, University of Houston
Upper New York	Rochester Institute of Technology	October, 1953	R. M. Campbell, Alfred University

Members of the Society are welcome at all Section Meetings

* **No Date Set.**

New Members

AGARWAL, PAUL D., Instructor in Electrical Engineering, Polytechnic Institute of Brooklyn, Brooklyn, N. Y. F. A. Wahlers, J. W. Hostetter.

AHONEN, CHARLES O., Associate Professor of Physics, Northeastern University, Boston, Mass. H. K. Brown, W. C. White.

ALDRICH, HARL P., JR., Assistant Professor of Soil Mechanics, Massachusetts Institute of Technology, Cambridge, Mass. A. J. Bone, H. R. Bartlett.

ANDERSON, EDWARD P., Assistant Professor of Electrical Engineering, Brigham Young University, Provo, Utah. G. W. Carter, R. D. Baker.

ARNESON, BLAYNE E., Instructor in Electrical Engineering, Milwaukee School of Engineering, Milwaukee, Wis. F. J. Van Zeeland, F. Kaufmann.

BACHELDER, ALFRED C., Assistant Professor of Mechanical Engineering, University of Rhode Island, Kingston, R. I. J. Parker, D. Bradbury.

BAILEY, JOHN A., Development Engineer, Thermal Power Sys. Division, General Electric Company, Schenectady, N. Y. N. P. Bailey, G. K. Palsgrove.

BALDWIN, DAVID, Instructor in English, Rensselaer Polytechnic Institute, Troy, N. Y. S. P. Olmsted, F. Abbuhl.

BARICH, STEVE S., Assistant Professor of Drawing, University of Minnesota, Minneapolis, Minn. R. F. Schuck, R. J. Moore.

BARRETT, THEODORE HARVEY, Associate Professor of Civil Engineering, Michigan College of Mining and Technology, Houghton, Mich. W. C. Polkinghorne, G. W. Swenson.

BARUS, CARL, Assistant Professor of Electrical Engineering, Swarthmore College, Swarthmore, Pa. J. D. McCrumm, H. M. Jenkins.

BATCH, JOHN M., Instructor in Mechanical Engineering, South Dakota State College, Brooklings, S. D. L. L. Amidon, E. E. Johnson.

BATEMAN, JOHN H., Professor of Civil Engineering, Louisiana State University, Baton Rouge, La. J. H. Bateman, A. B. Bronwell.

BELAVIC, ANDREW M., Instructor in Engineering Drawing, Case Institute of Technology, Cleveland, Ohio. O. M. Stone, W. E. Nudd.

BLAKEMORE, ROBERT E., Assistant Director of Student Personnel and Professor of Psychology, School of Mines, Rapid City, S. D. W. E. Wilson, E. E. Clark.

BLANCHARD, RALPH S., JR., Instructor in Mechanical Engineering, Northeastern University, Boston, Mass. A. J. Ferretti, E. E. Mills.

BLOMQUIST, GAIL C., Associate Professor of Civil Engineering, Michigan State College, East Lansing, Michigan. D. W. Ryckman, F. R. Theroux.

BRADFORD, HOWARD M., Instructor in Technical Institute, Purdue University, Lafayette, Ind. A. P. McDonald, A. W. Collins.

BURRELL, FREDERICK S., Assistant Professor of Mechanical Engineering, Swarthmore College, Swarthmore, Pa. J. D. McCrumm, W. J. Cope.

BURSIK, JOSEPH W., Instructor in Mechanical Engineering, Rensselaer Polytechnic Institute, Troy, N. Y. G. K. Palsgrove, J. G. Fairfield.

CALENDAR, H. L., Assistant Professor of General Engineering, Rutgers University, New Brunswick, N. J. S. P. Owens, M. T. Ayers.

CHAPITIS, WILLIAM J., Assistant Professor of English and Modern Languages, Colorado School of Mines, Golden, Colo. W. M. Richtmann, G. W. LeMaire.

CHUTE, GEORGE M., Professor of Electrical Engineering, University of Detroit, Detroit, Mich. R. W. Ahlquist, J. J. Uicker.

CLEARY, JOHN F., Instructor in Mechanical Engineering, Case Institute of Technology, Cleveland, Ohio. E. Laitala, G. L. Tuve.

CLIFFORD, LLOYD E., Instructor in Engineering, University of Santa Clara, Santa Clara, Calif. R. K. Pefley, H. H. Aiken.

COCHRANE, EDWARD L., Dean of Engineering, Massachusetts Institute of Technol-

ogy, Cambridge, Mass. J. R. Killian, Jr., H. L. Hazen.

COLE, LARRY, S., Professor and Head, Electrical Engineering, Utah State Agricultural College, Logan, Utah. J. E. Christiansen, M. J. Greaves.

CORLETT, ALBERT V., Head of Mining Dept., Queen's University, Kingston, Ont., Canada. A. Jackson, A. Butts, W. J. Rundle.

CREDE, CHARLES E., Chief Engineer, The Barry Corporation, 700 Pleasant Street, Watertown 72, Mass. H. K. Brown, E. E. Mills.

D'AVELLA, JOSEPH X., Instructor, Department of Industrial Management, Boston College, Chestnut Hill, Mass. W. R. Grogan, P. D. O'Donnell.

DEEMER, KENNETH C., Professor of Applied Mechanics, University of Kansas, Lawrence, Kans. F. L. Brown, R. S. Tait.

DICK, WILLIAM K., Instructor in Electrical Engineering, Washington University, St. Louis, Mo. J. W. Hammann, R. T. Webb.

DIOS, ZOLTAN B., Instructor in Electrical Engineering, University of Kansas, Lawrence, Kans. D. G. Wilson, W. P. Smith.

DOLAN, THEODORE, Instructor in General Engineering Drawing, University of Illinois, Chicago, Ill. C. J. Carlson, S. M. Futral, Jr.

DOYLE, LAWRENCE E., Associate Professor of Mechanical Engineering, University of Illinois, Urbana, Ill. K. J. Trigger, C. J. Starr.

DRUCKER, EUGENE E., Assistant Professor of Mechanical Engineering, U. S. Naval Postgraduate School, Monterey, Calif. H. M. Wright, P. J. Kiefer.

DYSON, LESLIE M., Assistant Professor of Electrical Engineering, Louisiana Polytechnic Institute, Ruston, La. B. T. Bogard, A. C. Thigpen.

EATON, MELVILLE E., Head of Engineering, University of Alabama Center, Mobile, Ala. W. McIlvaine, A. B. Bronwell.

ELBERFELD, JOHN, Dean of the College, Worcester Junior College, Worcester, Mass. W. C. White, W. T. Alexander.

ELMER, ROBERT W., Assistant Professor of English, Rensselaer Polytechnic Institute, Troy, N. Y. F. Abbuhl, S. P. Olmsted.

EVANS, JAMES P., Instructor in Basic Courses, Capitol Radio Engineering Institute, Washington, D. C. E. L. Radabaugh, A. Preisman.

FEZANDIE, EUGENE H., Professor of Mechanical Engineering, Stevens Institute of Technology, Hoboken, N. J. K. J. Moser, R. O. Vuilleumier.

FORRESTER, JAMES D., Professor of Mining Engineering, Missouri School of Mines, Rolla, Mo. C. L. Wilson, E. W. Carlton.

FRIEND, FREDERICK B., Lecturer in Applied Physics, University of Toronto, Toronto, Ont., Canada. L. S. Lauchland, K. B. Jackson.

GULLATT, SAM P., JR., Associate Professor of Electrical Engineering, Louisiana Polytechnic Institute, Ruston, La. B. T. Bogard, A. C. Thigpen.

HAGIST, WARREN M., Assistant Professor of Mechanical Engineering, University of Rhode Island, Kingston, R. I. D. Bradbury, F. Votta.

HANSEN, THOMAS L., Professor and Head, Department of Architecture and Architectural Engineering, University of Colorado, Boulder, Colo. C. L. Eckel, D. M. Carlson.

HASAN, MUBASHIR, Assistant Professor of Civil Engineering (on leave), The Punjab College of Engineering and Technology, Lahore, Pakistan. F. M. Dawson, E. B. Kurtz.

HAUER, NELSON, A., Head, Industrial Education Department, Louisiana State University, Baton Rouge, La. W. R. Woolrich, F. F. Pillet.

HEAFIELD, KENNETH, Associate Professor of English, Michigan College of M. & T., Houghton, Mich. F. L. Partlo, T. C. Sermon.

HEARNE, HOLLIS C., Associate Professor of Mathematics, Louisiana Polytechnic Institute, Ruston, La. A. C. Thigpen, B. T. Bogard.

HENDERSON, FRANK J., Chief Draftsman, Engineering, Jervis B. Webb Company, Detroit Mich. H. Gudebski, K. E. Smith.

HIXSON, WILLIAM A., Assistant Professor of Electrical Engineering, School of Mines, Rapid City, S. D. A. R. Colgan, E. B. Hunt.

HOFFMAN, SIDNEY, Assistant Professor of Mechanical Engineering, Syracuse University, Syracuse, N. Y. D. U. Greenwald, B. H. Norem.

HOLLY, NORMAN E., Assistant Director, Sinclair College, Dayton, Ohio. W. R. Woolrich, A. B. Bronwell.

HOLUB, RICHARD W., Instructor in English, Fairleigh Dickinson College, Rutherford, N. J. W. H. Foster, S. J. Tracy.

HUNTER, HAROLD O'D., Chairman, Division

of Engineering, Hillyer College, Hartford, Conn. G. Robley, W. J. Wohlenberg.

JAGGER, JAMES M., Personnel Director, Arthur D. Little, Inc., Cambridge, Mass. C. S. Keevil, L. C. Jenness.

JENSEN, IVAN R., Professor of Civil Engineering, University of North Dakota, Grand Forks, N. D. E. L. Lium, A. Koth.

JEWELL, ARTHUR D., Assistant Principal, Armstrong High School, Washington, D. C. L. J. Purnell, E. R. Welsh.

JOHNSON, ROBERT C., Assistant Professor of Chemical Engineering, Washington University, St. Louis, Mo. D. F. Chamberlain, W. P. Armstrong.

JONES, EVERETT L., Instructor in Engineering Extension, University of California, Los Angeles, Calif. J. C. Dillon, R. R. O'Neill.

KATZ, ADOLPH I., Assistant Professor of Textile Engineering, Lowell Textile Institute, Lowell, Mass. M. Hindle, M. E. Gelinas.

KEMP, C. ERNEST, Assistant Professor of Geology, Michigan College of M. & T., Sault Ste. Marie, Mich. H. L. Crawford, C. Russell.

KENERSON, WALDO I., Professor of Civil Engineering, Michigan State College, East Lansing, Mich. D. W. Ryckman, D. J. Renwick.

KIBBEY, DONALD R., Instructor in Industrial Engineering, Ohio State University, Columbus, Ohio. P. N. Lehoczky, L. D. Jones.

KISTLER, SAMUEL S., Dean, College of Engineering, University of Utah, Salt Lake City, Utah. A. L. Taylor, M. E. Van Valkenburg, O. C. Haycock.

KLINE, STEPHEN J., Assistant Professor of Mechanical Engineering, Stanford University, Stanford, Calif. J. B. Franzini, W. G. Ireson.

KRINSKY, HERMAN Y., Instructor in Chemical Engineering, Pratt Institute, Brooklyn, N. Y. R. F. Shaffer, K. E. Quier.

KROMHOUT, ROBERT A., Instructor in Physics, University of Illinois, Urbana, Ill. A. F. Silkett, W. K. LeBold.

LEMLICH, ROBERT, Assistant Professor of Chemical Engineering, University of Cincinnati, Cincinnati, Ohio. H. K. Justice, W. Licht.

LEONARDS, GERALD A., Assistant Professor of Soil Mechanics, Purdue University, Lafayette, Ind. F. W. Stubbs, Jr., M. B. Scott.

LYNN, WALTER R., Instructor in Civil Engineering, University of Miami, Miami, Fla. M. I. Mantell, J. H. Clouse.

MCBRIDE, EDWARD J., Chairman, Department of Mechanical Engineering, University of Kansas, Lawrence, Kans. L. O. Hanson, R. S. Tait.

MCCONNELL, HOWARD M., Assistant Professor of Electrical Engineering, Carnegie Institute of Technology, Pittsburgh, Pa. W. P. Caywood, G. W. Penney.

MCCUAN, MARVIN G., Professor and Chairman, Department of Engineering and Mathematics, Amarillo College, Amarillo, Tex. W. W. DeVaney, W. E. Street.

MCWILLIAMS, ROBERT L., Staff Assistant, Educational Relations, Public Relations Dept., General Motors Corp., Detroit, Mich. K. A. Meade, E. L. Yates.

MORECOCK, EARLE M., Supervisor Electrical Department, Rochester Institute of Technology, Rochester, N. Y. G. H. LeCain, L. F. Smith.

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Young Faculty Members . . . . .

PAPER COMPETITION

ELIGIBILITY: Members of ASEE not over 36 years of age in June, 1953.

AWARDS: First prize $200—Second prize $100.
Awards will be presented to recipients at the Banquet at the Annual Meeting of ASEE, University of Florida, June 25, 1953.

SUBJECT: Papers should deal with some constructive phase of improvement of engineering education. Participants are encouraged to select their own subject matter and titles within the broad framework of improvement of engineering education. In general, the papers should not be of a technical nature. The following are suggestions of the type of subject matter to consider:

a. How can the student learn to deal with new and unfamiliar situations with originality and well-ordered professional thinking?

b. What are the most important qualifications of undergraduate teachers of engineering?

JUDGING: Each Section will appoint its own judging committee and select one winning paper. The winning papers from the Sections will be reviewed by a national judging committee for the final awards.

SUBMISSION OF ENTRIES: Papers can be submitted to the following persons in the ASEE Section in which the participant resides:

Section	*Final Date*	*Submit Entry To:*
Allegheny	April 1, 1953	L. Zee Seltzer, West Virginia University, Morgantown, W. Va.
Missouri	April 1, 1953	F. H. Conrad, School of Mines, Rolla, Mo.
National Capital	March 23, 1953	L. K. Downing, Howard University, Washington, D. C.
New England	March 15, 1953	E. T. Donovan, University of New Hampshire, Durham, N. H.
North-Midwest	April 1, 1953	S. J. Chamberlain, Iowa State College, Ames, Iowa
Ohio	March 14, 1953	H. K. Justice, University of Cincinnati, Cincinnati, Ohio
Pacific-Northwest	March 15, 1953	J. P. Spielman, State College of Washington, Pullman, Wash.
Rocky Mountain	March 10, 1953	R. E. Leffel, University of Colorado, Boulder, Colo.
Southeastern	Feb. 27, 1953	M. Baker, University of Kentucky, Lexington, Ky.
Southwestern	April 2, 1953	R. D. Slonneger, University of Texas, Austin, Tex.
Upper New York	March 15, 1953	A. D. Taylor, 18 Campus Drive East, Snyder 21, N. Y.

The following Sections have not indicated a final date for entries, but papers submitted prior to March 15 will be considered:

Illinois-Indiana	—	H. A. Moench, Rose Polytechnic Institute, Terre Haute, Ind.
Kansas-Nebraska	—	M. A. Durland, Kansas State College, Manhattan, Kans.
Michigan	—	C. C. Winn, Detroit Inst. of Technology, Detroit, Mich.
Middle Atlantic	—	W. B. Plank, Lafayette College, Easton, Pa.
Pacific-Southwest	—	C. E. Cherry, College of Marin, Kentfield, Calif.

Sections and Branches

The Fall Meeting of the **Middle Atlantic Section** of the ASEE was held at Manhattan College in New York City on December 6, 1952. Reverend Brother Bonaventure Thomas, President of Manhattan College, in welcoming the visitors suggested that they should strive as educators, not only to teach engineering fundamentals but to infiltrate those principles which are socially and morally good. Chairman W. B. Plank presided over this meeting whose topic was "The Role of Professionalism in Engineering Education." Speakers included E. J. Nunan, W. J. McCarthy and J. L. McManus. A second general session, with Reverend Brother Bernard presiding, was devoted to the topic "Transition—College to Training in Industry," presented by Dwayne Orton, assisted by C. S. Purnell and D. J. O'Connell. New Section officers include: Chairman, C. Bonilla; Vice-Chairman, C. Burrill; Council Representative, T. Saville.

* * *

The thirty-third annual meeting of the **Kansas-Nebraska Section** convened on October 24, 1952 in the parlors of Plymouth Congregational Church of Lawrence, Kansas. M. A. Durland presided. W. R. Woolrich, President of ASEE, spoke on the subject "Should We Up-Grade the Engineering Profession to Higher Achievement Levels?" At the close of his address Dean Woolrich answered questions from the floor. The following officers were elected: Chairman, M. H. Barnard; Vice-Chairman, J. E. Ward; Secretary-Treasurer, P. G. Hausman; Council Representative, M. A. Durland. It was announced that the meeting for next year would be held at Kansas State College.

* * *

The **Upper New York Section** of the ASEE held its seventh annual meeting at Alfred University on October 10 and 11, 1952. The General Session on Saturday morning was highlighted by a panel discussion on the topic "The Trend of Engineering Education in 1952." Speakers were: J. Seidlin, R. R. Dry, S. C. Hollister, N. L. Freeman, M. M. Boring and C. V. Newsom. A. B. Bronwell, National Secretary of ASEE, and M. M. Boring, National Vice-President, attended the meeting. The following officers were elected: Chairman, F. E. Almstead; Vice-Chairman, N. A. Christensen; Secretary-Treasurer, A. D. Taylor. The next annual meeting of the Section, with the Rochester Institute of Technology serving as host for the Technical Institute group, will be held in October, 1953.

In the News

"Who's Who in Engineering" announces the beginning of the compilation of the 7th edition, the first revision since 1948. The Advisory Committee of Engineers Joint Council on the publication met with the editor and publisher recently and drew up the minimum qualifications for inclusion in the volume.

The method of revision that will be followed includes the resubmission of their material to all those recorded in the 6th edition; the extension of invitations to supply data to a large list of engineers who have been variously recommended for the volume during the four years since the appearance of the 6th edition; the extension of invitations to engineers in all branches of the profession not now included, whose activities are indicative of the quality of their professional accomplishments; the issuance of invitations to engineers recommended by institutions and organizations with which they have been identified.

The Advisory Committee of Engineers Joint Council is composed of: A. A. Potter, Chairman, Dean of Engineering, Purdue University; George W. Bailey, Seretary, The Institute of Radio Engineers; Prof. A. B. Bronwell, Secretary, American Society for Engineering Education; Col. W. N. Carey, Secretary, American Society of Civil Engineers; Col. C. E. Davies, Secretary, The American Society of Mechanical Engineers; H. H. Henline, Secretary, American Institute of Electrical Engineers; S. Paul Johnston, Director, Institute of Aeronautical Sciences; Paul H. Robbins, Executive Director, National Society of Professional Engineers; E. H. Robie, Secretary, American Institute of Mining and Metallurgical Engineers; S. L. Tyler, Secretary, American Institute of Chemical Engineers; John A. C. Warner, Secretary, Society of Automotive Engineers; and L. Austin Wright, Secretary, Engineering Institute of Canada.

The importance of the publication to the profession and to the country at large, a point in which there is general concurrence, is stressed. The volume is produced under careful editorship, with ready acceptance by the publisher of workable suggestions from professional groups upon coverage.

The minimum qualifications for inclusion referred to above are as follows:

1. Engineers of at least ten years active practice, at least five years of which have been in responsible charge of important engineering work.

2. Teachers of engineering subjects in colleges or schools of accepted standing who have taught such subjects for at least ten years, at least five years of which have been in responsible charge of a major engineering course in such college or school.

College Notes

Announce National Collegiate-Industry-Government Conference on Instrumentation

The Electrical Engineering Department of **Michigan State College**, in cooperation with the National Science Foundation, the National Bureau of Standards, the Instrument Society of America, and the American Society for Engineering Education, announces an invitational National Collegiate-Industry-Government Conference on Instrumentation to be held on its campus, March 19–20, 1953.

The Conference is being called in recognition of the growing importance and potential of instrumentation in research and production, and to the national defense. The objectives of the Conference are:

a. To relate the role and needs of Instrumentation in production and research to college interests and responsibilities,
b. To review current Instrumentation activities in the colleges,
c. To suggest specific activities the colleges might undertake in this field,
d. To suggest specific ways by which Industry might assist the colleges in these activities.

Participating in the program and representing the sponsoring groups will be Paul Klopsteg, Director of the Mathematical, Engineering and Physical Sciences Div. of the National Science Foundation, A. V. Astin, Director of the National Bureau of Standards, Porter Hart, President of the Instrument Society of America, and E. A. Walker, Dean of Engineering at Pennsylvania State College.

Others on the program include: from industry, G. M. Rassweiler, Assistant Chief, Physics-Instrumentation Lab., General Motors Technical Center, J. B. MacMahon, Republic Flow Meters Company, George Muschamp, Vice-President, Brown Instrument Company, R. T. Sheen, Vice-President, Milton Roy Company; from Government, W. A. Wildhack, Chief, Office of Basic Instrumentation, N. B. S.; from the colleges, J. D. Trimmer, University of Tennessee, R. W. Jones, Northwestern University, C. S. Draper, M.I.T., H. C. Roberts, University of Illinois, D. P. Eckman, Case Institute and R. J. Jeffries and M. Muelder, Michigan State College.

Educational and Industrial administrators and others interested in the field of Instrumentation who would like additional information concerning the Conference should write to Professor R. J. Jeffries, Department of Electrical Engineering, Michigan State College, East Lansing, Michigan, at once, as attendance will be limited.

* * *

The departments of electrical engineering and physics of the **University of Illinois** College of Engineering, in cooperation with several leading companies in the electronics industry, will conduct a Summer School on Semiconductors and Transistor Electronics at Urbana, Ill., June 22–July 17, 1953. Courses will be offered in three areas—a general survey of semiconductors, physics of transistors, and transistor circuits. Lecturers will include outstanding scientists from industrial laboratories as well as regular University of

Illinois staff members. The school will be part of the Summer Session of the University, so that graduate-level academic credit can be given if desired. Inquiries should be addressed to the Department of Electrical Engineering, University of Illinois, Urbana, Ill.

* * *

Dean S. S. Steinberg, chairman of the ASEE Committee on International Relations and Dean of Engineering of the **University of Maryland**, attended the Inter-American Convention of the American Society of Civil Engineers at San Juan, Puerto Rico. He will represent the President's Conference on Industrial Safety, of which he is chairman of the Committee on Education. He will present a paper on "Safety Integration into Engineering Curricula."

* * *

The appointment of Dr. Ely Mencher, formerly Senior Field Geologist and Research Geologist with the Socony Vacuum Oil Company of Venezuela, as Associate Professor of Geology in the Department of Geology and Geophysics at the **Massachusetts Institute of Technology** has been announced. At M.I.T. Dr. Mencher will conduct courses in Stratigraphy and Petroleum Geology and will continue his research on the Geology of South America.

* * *

Dr. Herschel H. Cudd has been appointed Acting Director of **Georgia Tech's** State Engineering Experiment Station. He will assume the duties of Dr. Gerald A. Rosselot, former Director, who recently resigned. Dr. Cudd, who has served as head of the Station's Chemical Sciences Division since 1950, possesses a broad background of industrial research experience, including employment with du Pont's Rayon Technical Division, International Minerals and Chemicals Corp., and West Point Manufacturing Company. Prior to joining the Station's staff, Dr. Cudd was director of West Point's Lantuck Division. Dr. Cudd received his B.S. in Chemistry from Texas A. & I. in 1933 and his Ph.D. in Physical Chemistry from the University of Texas in 1941.

* * *

The Daniel and Florence Guggenheim Foundation will grant a total of $36,000 for 1953 Guggenheim Jet Propulsion Fellowships for graduate study in rocket and jet propulsion engineering at the **California Institute of Technology** and at Princeton University.

* * *

New head of the department of theoretical and applied mechanics in the **University of Illinois** college of engineering is Professor Thomas J. Dolan. The board of trustees named him on Nov. 28 as successor to Professor Fred B. Seely, who has reached retirement age. Prof. Dolan is president of the Society for Experimental Stress Analysis, chairman of an American Society for Testing Materials committee on fatigue, a consultant for the National Science Foundation, and latest winner of the Templin award of the ASTM. He served as a delegate to the World Metallurgical Congress in 1951, and as a participant in the Stockholm conference on the fatigue of metals in that same year.

* * *

Cornell University has set up a special 5-year curriculum in agricultural engineering and will grant a new professional degree—bachelor of agricultural engineering—to students who successfully complete the work.

* * *

New York University will initiate a program of graduate courses in transportation engineering with the academic term beginning in February, 1953. The new program will emphasize modern highway planning, design, and construction; traffic engineering; and airport design. The course offerings are primarily intended for persons holding undergraduate degrees in

Civil Engineering. Each course may be taken as a portion of a program leading to an advanced degree, or as a single course by a qualified special student. Completion of the entire series constitutes a measure of specialization in this phase of civil engineering.

* * *

Graduate study in technical writing is to be offered by **Rensselaer Polytechnic Institute** beginning with the next college year. The degree of master of science is to be awarded on satisfactory completion of two semesters of work. Courses are designed to develop clear, grammatical and interesting writing on technical subjects. The English department is to direct the program.

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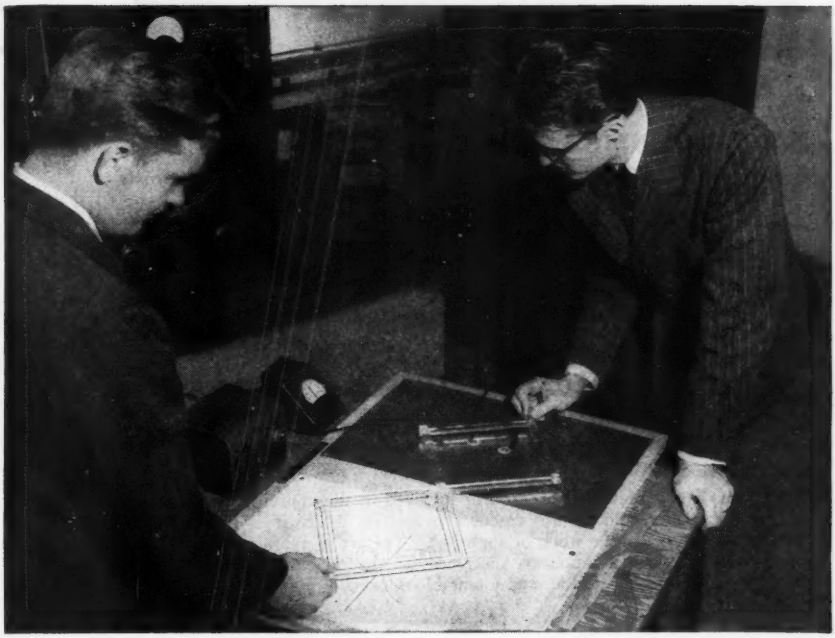

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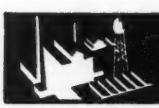

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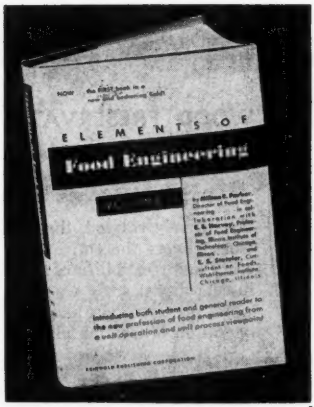

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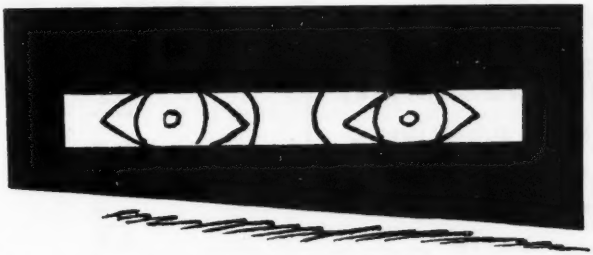

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